Vol. 48 No. 2 October 1954

Quarterly

of the

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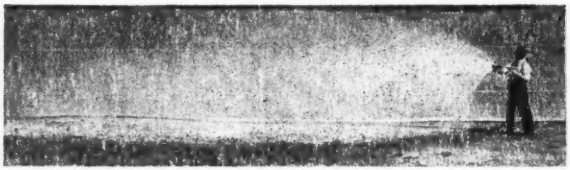

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Vol. 48, No. 2 October 1954

Quarterly

The Standard Technical Journal of Fire Protection for More Than Forty Years

The NFPA is a non-profit technical and educational organization devoted to the reduction of loss of life and property by fire with a total membership of 15,000. The *Quarterly* is one of the publications regularly provided to members. Other membership publications include a monthly *Fire News*, *Advance Reports* and *Proceedings* of the Annual Meetings, a *Year Book*, and many leaflets, pamphlets and posters issued throughout the year on fire prevention and control.

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National Fire Protection Association
International

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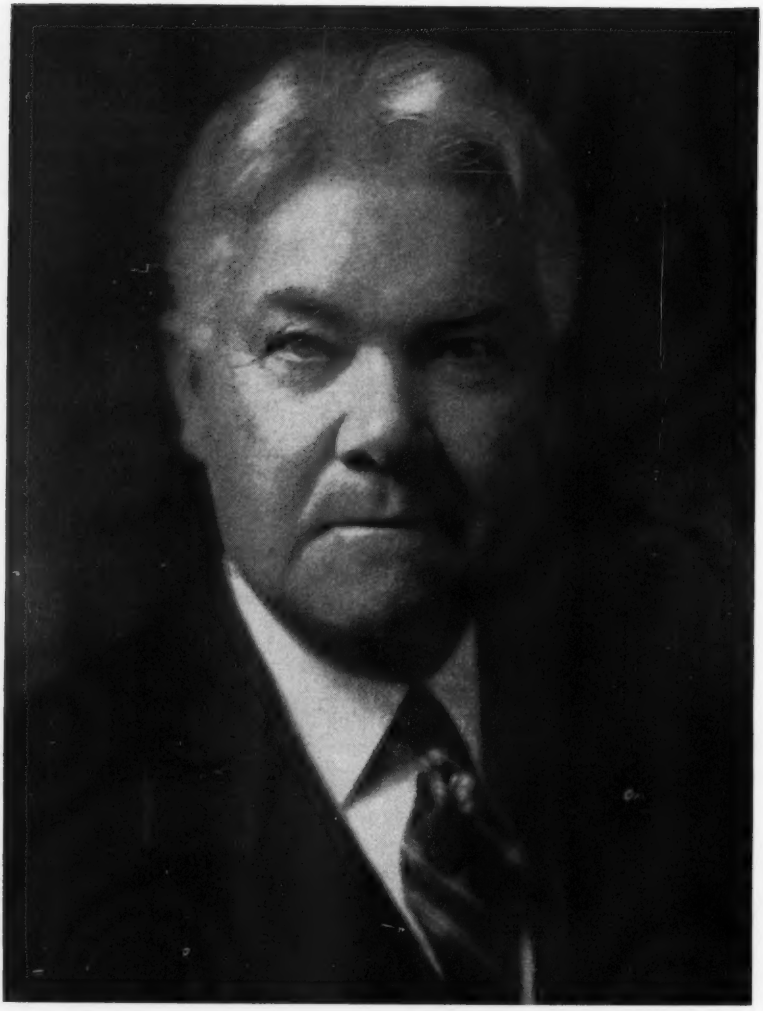


Franklin H. Wentworth

NFPA Secretary and Managing Director, 1909-1939

Died October 4, 1954

Franklin H. Wentworth

1866-1954

Franklin Wentworth died on October 4, 1954 in New York. In a letter we received from him in August, he told of his plans to visit his daughter in Egypt and to stop off in Boston on his way back to his home in Redondo Beach, California. Mr. Wentworth was taken ill in Barcelona en route and was flown to New York upon advice of his physician. He leaves Mrs. Wentworth, a daughter, Cynthia, and four sons, Brandon, Strafford, Chapman and Hampden.

Mr. Wentworth was born in Chicago, March 27, 1866 and attended the public schools there. He was an electrical inspector for the Western (Insurance) Union and was associated with William Merrill at the time of the founding of Underwriters' Laboratories. Mr. Merrill persuaded Mr. Wentworth to become the first paid secretary and editor of the Quarterly of NFPA in 1909. Mr. Wentworth came to Boston and set up the first permanent headquarters of NFPA at 87 Milk Street. For many years he also represented the Underwriters' Laboratories in New England. From 1909 until his retirement as managing director of NFPA in 1939, Mr. Wentworth devoted his life to the building of our Association. Upon retirement he moved to California. His last appearance before an NFPA gathering was at our regional conference in Los Angeles in 1951 where he greeted those in attendance.

Many of our members will remember Mr. Wentworth best for his remarkably effective writing and speaking ability and for his crusading zeal for the cause of fire protection and prevention. Throughout his thirty years of service to our cause, Franklin Wentworth zealously fostered and developed the fair and impartial attitude towards all phases of our work which has meant so much to the reputation of the NFPA. His many and great contributions to the Association will long be remembered.

Let's Prevent Nursing Home Fire Casualties*

By Chester I. Babcock

Manager, NFPA Fire Record Department

Lest anyone question the need for concern with life safety in nursing homes let me cite a figure or two from a recent study by the National Fire Protection Association of 100 nursing home fires. Of these 100 fires, deaths or injuries occurred in 49. Among the fires in this study were some of the notorious nursing home fires in which many lives were lost. For this reason, and also because of the smallness of the sample, it would be incorrect to draw the conclusion that a casualty occurs in one of every two nursing home fires. However, when the 49 nursing home fires with casualties in the 100 studied is compared with 24 in 100 for hospitals, 27 in 100 for mental institutions and 15 in 100 for orphanages, there is no doubt that nursing home fire experience is disproportionately bad and in need of improvement.

Everyone in any way connected with nursing home fire safety — nursing home operators, legislators, law enforcement officers and fire protection engineers — if not legally responsible, is certainly morally obligated to do what he can to make available to our aged and infirm reasonably safe places to live. Please note the words "reasonably safe." The cost of *complete* fire safety for nursing homes, as for other occupancies, is often such a compelling factor that economic considerations must temper the desire for the ideal — complete fire safety. But, fortunately, there are many ways to improve the life safety of nursing homes that are economically feasible. Although the result may not be a home completely free from the dangers of fire, it will be one in which the possibility of a serious fire is remote.

What are these steps that can be taken and why do we urge them? The answers to these questions are in the fire record. From the NFPA's study of nursing home fires, it was found that violations of certain well-known principles of fire safety were responsible for those fires in which casualties occurred and property damage was extensive. The evidence from these fires shows just what these principles of fire safety are and why they have so great a bearing on the safety of those in nursing homes. These principles fall into four groups: 1, those pertaining to the building; 2, those relating to the building's contents; 3, those pertaining to the people in the building; and 4, fundamental principles of fire detection and control.

Building Principles

Among the many features of nursing home building construction that have a bearing on life safety, five were shown by the fire records to be of particular importance.

*Based upon a paper presented in Boston, September 23, 1954, at a conference on nursing home fire safety. The conference was under the auspices of a Special Commission of the Massachusetts Legislature to study and investigate means and methods for improving protection against fire in homes and institutions for the sick and aged.

Acme

Walker's Convalescent Home; near Amarillo, Texas, December 22, 1950.

Fire Resistance of the Building

Let us first consider the fire resistance of the building. The ideal building is one constructed of fire-resistive structural members. Although it is true that casualties are rarely due to building collapse in fires, there are certain other weaknesses in design often found in buildings that are not fire-resistive, such as combustible concealed spaces, that have frequently been factors in fire casualties.

It is also true that flimsy, combustible construction may contribute to fire spread. A nursing home fire near Amarillo, Texas in 1950 is an example. A defective gas-fired furnace was the cause. Although the fire occurred in mid-afternoon when many attendants and friends of occupants were in the 1-story wooden building, flames enveloped the combustible structure so rapidly that 10 of the 47 elderly occupants could not be saved.

As other fires are mentioned it will be noted that all occurred in combustible buildings and that in most instances the combustibility of the building was an important factor in the loss of life. It is significant that we have no records of a fire casualty or serious fire in a nursing home built of noncombustible or fire-resistive materials. It is here, perhaps, more than anywhere else, that economic considerations may force a compromise with ideal fire safety. But if it is necessary to use combustible buildings for nursing homes, additional safeguards should be provided for the occupants, such as confinement of nonambulatory persons to the first floor, and the installation of sprinklers.

Exits

Of all the steps that should be taken to improve the life safety of nursing homes, provision of means for getting the occupants safely out in case of fire heads the list. No matter how well constructed the building or how strong the fire protection, there is always the possibility that the building will have to be evacuated. This is one feature of fire safety for nursing homes that under no circumstances should

be compromised by economic considerations. Recommendations for exits are spelled out in detail in the NFPA Building Exits Code, but for purposes of this discussion, it is sufficient to mention the recommendations for at least two exits from each floor, that exits be located as remote as practicable from each other, that they be of adequate width, lighted and marked, and that interior exits be enclosed.*

Exits, good or bad, are factors in almost every nursing home fire. Thirty-three occupants of a home for aged at St. Johns, Newfoundland lost their lives in 1948 because a single open stairway was the only way out from each of the two separate sections of the building. The fire started at a defective oil range in a second story kitchen and, by the time firemen had arrived, had spread up the open stairs and into many rooms on upper floors. Only a few persons were alive to be rescued by firemen. Three had jumped and were killed.

David Bier

Hospice St. Cunegonde; Montreal, Quebec, June 15, 1951.

*The NFPA Committee on Safety to Life has under consideration a proposed addition to the Building Exits Code dealing specifically with exits for nursing, convalescent and old age homes.

Press Association

Hull Nursing Home; St. Johns, Newfoundland, February 11, 1948.

An enclosed rear stairway had much to do with the safe escape of 23 occupants, of whom 21 were bedridden, from a nursing home fire in Waterloo, New York on April 11, 1953. It was also fortunate that the fire had not made much headway in the basement when discovered at 8 in the morning. Smoke was filling the building when firemen arrived and had already made the open front stairway impassable. Had it not been for the enclosed rear stairway and the prompt arrival of a large number of firemen, it is doubtful if the occupants could have been saved.

San Francisco Call-Bulletin

Little Sisters of the Poor Home for Aged, San Francisco, California, April 15, 1952.

Enclosure of stairways is important to the life-safety of nursing homes for two reasons: the enclosure provides a safe exitway for occupants, and is a barrier to vertical spread of fire, heat and smoke to upper stories. It is a safe assumption that the deaths of 28 aged women and six employees would not have occurred at the Montreal Hospice fire in 1951 had the stairways been enclosed.* The fire originated in the second story corridor, spread through the corridor to an open stairway and then went up the stairway trapping elderly victims and some of the attendants in rooms in the third, fourth and fifth stories. Many fire protection weaknesses combined to cause this disaster including lack of sprinklers and combustible finish in the corridors, but despite these conditions, it is probable that the women in the upper stories could have reached safety had stairways been enclosed.

*See July 1951 Quarterly for detailed report.

Fire Stopping

About one-third of the nursing home fires studied originated in the basement, and, in many cases, because walls were not fire-stopped, the fires spread within wall spaces to upper stories. A San Francisco nursing home had to be evacuated shortly after midnight on April 15, 1952 because

fire that flared up from a pool of oil near the oil burner in the boiler room entered nonfirestopped concealed wall spaces and spread vertically through the 5-story building. Although sprinklers operated to give the alarm and extinguish the fire in the boiler room, they had no effect on flames that had entered unsprinklered wall spaces and were spreading out of range of sprinklers. Had the relatively simple and inexpensive procedure of firestopping the walls at the boiler room basement ceiling been taken, the extensive damage that resulted could have been averted. Firemen had to open up walls and put out the fire with hose streams.

Segregation of Hazardous Areas

From many studies of fire experience, fire protection engineers have pinpointed certain places in buildings, such as furnace rooms, storage areas and paint shops, as particularly susceptible to fire, and it has long been an axiom of fire protection engineering that whenever possible these areas should be cut off from the rest of the building with fire-resistive walls, ceilings and floors. Many of the fire casualties in nursing homes, including the five that occurred in Nicollette, West Virginia on February 26, 1950, would not have occurred had areas known to be fire breeders been cut off. This fire started near the furnace in the basement when heat from the furnace and flue pipe ignited the combustible walls and ceiling. Flames spread laterally through the basement to an open stairway and were well on their way to the second story when the superintendent and his wife were awakened by smoke at 2:20 A.M. The 34 who escaped made their ways to safety down outside metal stairways or were rescued over ladders.

Interior Finish

Fire tests and fire experience have shown that flames spread rapidly over the surface of combustible fibreboard and plywood, yet we frequently find these materials used in abundance in nursing homes rather than plaster, plasterboard or some other noncombustible interior finish. Where combustible fibreboard or plywood is used the flame-spread hazard may be

Wood County Infirmary; Nicolette, West Virginia, February 26, 1950.

W. A. McDonnell

Cedar Grove Nursing Home; Hillsboro, Missouri, October 31, 1952.

reduced by applying an approved flame proofing paint.*

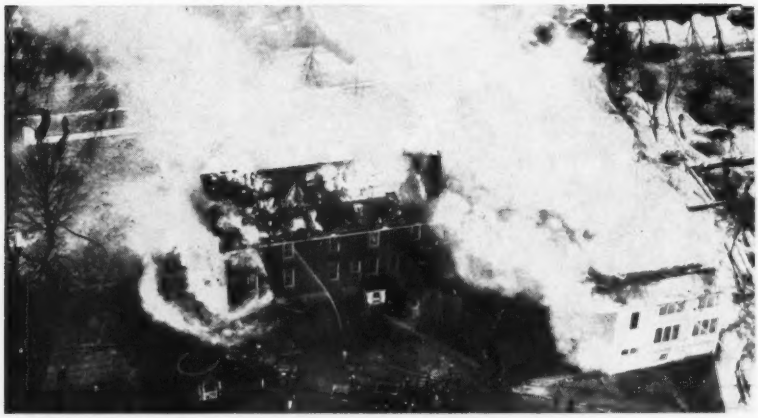
Highly combustible interior finish has been a factor in some of the notorious nursing home fires: the Garfield Heights, Ohio fire of 1946 in which 14 were killed; the Largo, Florida fire of 1953 that took 33 lives; and the Hillsboro, Missouri fire of 1953 in which 20 patients died. In each of these disasters several fire safety weaknesses were at work, but from the evidence, the combustibility of the interior finish was an outstanding reason that there was not time to get the occupants out. In the Hillsboro fire† it is true that the fire would not have started had a light fixture in a first floor linen room been installed in accordance with provisions of the National Electrical Code, and the fire presumably would not have spread up the stairs had the stairway been enclosed. The facts remain, however, that the light fixture installation was substandard and the stairway to the second and third stories was open. Consequently, because the linen room and adjacent hallway were lined with combustible fibreboard, fire originating at the light fixture spread along the walls and ceiling and up the open stairway so rapidly that of the 70 occupants, 20 were killed and 37 more were injured.

Contents Features

So much for features of the building itself that should be given attention if we hope to improve materially the life safety of nursing homes. Next let us think a bit about the contents of these

*The rate of flame spread on one side (in some instances both sides) of most combustible fibreboards now on the market has been reduced by a flame retardant paint treatment applied by the manufacturer. See also Fire Hazards of Building Boards, page 123.

†See January 1953 Quarterly for detailed report.



Press Association

Iowa Lutheran Home for Aged; Madrid, Iowa, January 16, 1948.

buildings. The principal contents hazards can be divided into two groups: those associated with the so-called building services, that is, heat and light; and those involving the furnishings and decorations of the building.

Building Services

Building services are *the most frequent cause* of nursing home fires, with defects in heating equipment accounting for 20 per cent of the fires, and electrical wiring and appliances 10 per cent. This being the case, it is obvious that any program to improve the life safety of these homes must include consideration of heating and electrical equipment. In both cases, the records show that the defect causing the fire can be traced directly to a substandard installation or to poor maintenance. As evidence, three cases of fires caused by faulty heating equipment have already been cited: the Amarillo, Texas fire caused by a defective gas-fired furnace; the San Francisco fire caused by overflow of an oil burner; and the Nicollette, West Virginia fire that broke out because the furnace was installed beneath a combustible ceiling.

Three elderly persons lost their lives in a Branford, Connecticut nursing home in 1952 when fire caused by a defective oil-fired space heater broke out on the first floor. On discovering the blaze at 11:15 A.M. the owner delayed the alarm until after an unsuccessful attempt to put out the fire with a small fire extinguisher. Before the fire department arrived flames had spread up an open stairway and were in control of the building.

A nursing home fire in 1948, at Madrid, Iowa was traced to overheated wiring in an employee's quarters in the attic. When the employee discovered that the electric heaters he used to warm his room blew fuses repeatedly, he solved the problem by putting in larger fuses. Thereafter, not only did his room get hot but so did the overloaded wiring and it was not long before fire was burning in the attic walls. Attendants and firemen removed all patients from lower floors before fire burned down through the unsprinklered building.

Combustible Contents

It would be impracticable or impossible to substitute noncombustible furnishings for all that are combustible. What can be done, however, is to discontinue the use of all nonessential combustible contents, such as flammable decorations, and to use noncombustible substitutes where available. Combustible material should be removed from the building as soon as it has served its purpose — rubbish, newspapers, old mattresses.

Any discussion of nursing home fires attributed to combustible contents must make mention of the Hartford, Connecticut convalescent home fire in 1945 in which 19 were killed and 30 injured.* Most of the casualties involved elderly persons. The fire originated on flammable cotton at the base of a Christmas tree in a first floor office. Telephone wires quickly burned, delaying fire department notification, and when the employee who discovered the fire found that he could not operate a fire extinguisher he became panicky and ran from the office leaving the door open. Fire followed him out of the room and spread up an adjacent open stairway to upper stories.

*See January 1946 Quarterly for detailed report.

Occupant Features

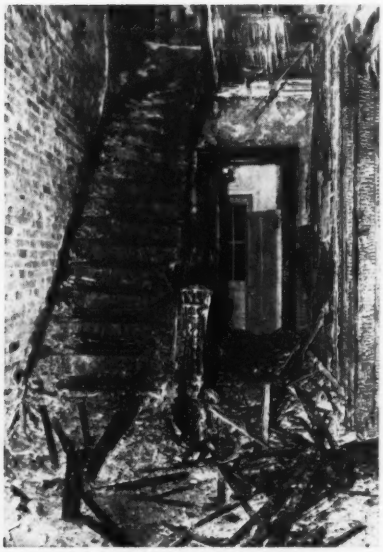
Life safety from fire is more than a matter of *things;* it also involves *people* and the behavior of the employee in the Hartford fire just cited is one example of the need for more attention to the behavior of attendants and occupants.

Attendants

Consider the attendants. The first requisite for the effective handling of a fire

United Press

Northam Home for Aged; Branford, Connecticut, May 1, 1952.



Niles Street Convalescent Hospital; Hartford, Connecticut, December 24, 1945.

emergency is that at least one nurse or qualified attendant be awake and on duty at all times to detect a fire in its incipiency, to call the fire department and start moving occupants to safety.

A nursing home near Largo, Florida was destroyed in 1953 with the loss of 32 patients and an attendant.* Just what caused the fire was never definitely determined although a fault in an electric motor on a deep freeze in the kitchen was a likely suspect. Whatever the cause, it was not so much responsible for the terrible loss of life as were various fire safety weaknesses, including highly combustible interior finish and absence of automatic protection. Of prime importance was the fact that no attendant was awake and on duty to discover the fire when it was still small and when there would still have

*See April 1953 Quarterly for detailed report.

United Press

Littlefield's Nursing Home; near Largo, Florida, March 29, 1953.

United Press

Kincaid Nursing Home; near Kincaid, Kansas, September 17, 1954.

been time to awaken and remove the elderly occupants. An elderly patient was the first to discover the fire. It was then 3:15 in the morning. Lights had already been put out of order by the fire and smoke was rapidly filling the building as the patient aroused the sleeping owners. After wasting a few valuable minutes discharging fire extinguishers in the general direction of flames in the kitchen, the owners rushed through the building opening doors and shouting to patients to get out. But the occupants were typical of those in nursing homes — old, feeble and in some instances without their full mental faculties. On being awakened from a sound sleep they reacted in a stunned and uncomprehending manner and instead of proceeding into the smoke-filled dark corridors or climbing out ground floor windows, they stayed in their beds. A few bedridden were carried out but very little assistance could be offered to the others before wind-swept flames raced through the highly combustible building.

A nursing home attendant who is not well trained in his or her responsibilities at time of fire is little better than no attendant at all. The fire record indicates that some nursing home attendants, although they may be well trained in providing for the day-to-day needs of the people under their care, show a complete lack of training when it comes to a fire emergency.

On September 17, 1954, seven of ten patients in a nursing home near Kincaid, Kansas lost their lives in a fire. Testimony is still being taken from survivors but information obtained so far leaves little doubt that lack of employee training con-

tributed to the loss of life. The owner and his wife were away at the time and had left their home in the care of three attendants, none of whom had been instructed in what to do in case of fire. One of the three had been on the job only a day, and another only a week. No one was required to stay awake and on duty during the night. The fire started in a first floor recreation room and was not discovered until an attendant on the second floor was awakened by the smoke. There was still time to get people out through an emergency exit from the second story but apparently none of the attendants made any attempt to do this and without someone to guide them, the old people, although all were able to walk, did exactly as their counterparts at Largo, Florida — stayed in their rooms.

Ignorance of what to do in case of fire was a factor in the nursing home tragedy at Watervliet, Michigan, February 19, 1954, at which eight of the ten occupants lost their lives. The fire originated in the glassed-in sleeping porch on the first floor when a window curtain came in contact with a portable electric heater. Screams of "Fire!" from a bed-ridden patient on the porch summoned the attendant who, on seeing the fire, ran upstairs and awakened the owner. The two then came downstairs and on finding that they could not get to a telephone on the porch, *both* went to a neighbor's house to call the fire department. Neither made any effort to get the ten people out of the building. Although the building was a mass of flames when the fire department arrived, there is pretty good evidence that some of the victims could have been rescued before flames enveloped the building, had an attendant made an immediate start to remove them to safety. An elderly occupant on the second floor, on hearing the commotion, got up, dressed, came downstairs and picked up his wife who was a patient on the first floor and carried her out through the back door.

Associated Press

Shimer Convalescent Home; Watervliet, Michigan, February 19, 1954.

Philadelphia Fire Department

Presbyterian Home for Aged Women; Philadelphia, Pennsylvania, October 21, 1953.

That the 200 aged women in a Philadelphia nursing home were removed to safety on October 21, 1953 was due primarily to the excellent work of the Philadelphia Fire Department rather than to efforts of the untrained employees. The fire started in a third story room during the afternoon when an electric iron ignited a telephone book. (The book was serving as an ironing board.) On discovering the fire, the attendants neither called the fire department nor commenced removal of occupants, but, instead, tried to put out the fire themselves. They assembled and used twelve 2½-gallon soda-acid extinguishers in an unsuccessful attempt to extinguish the blaze. Flames spread up an open stairway and to the attic of the unsprinklered 3-story building.

Careless Smoking

Careless smoking is responsible for about one out of four nursing home fires, showing that the patients themselves are not blameless when nursing home fire experience is considered. Instruction of these people in the importance of following a few smoking rules — smoking only in designated rooms, no smoking in sleeping rooms except when attendants are present, use of safely designed ash trays* —will pay dividends in fewer fires.

Six men were killed in a nursing home at Billings, Montana in 1953 when fire caused by careless smoking spread rapidly over combustible fibreboard on walls and ceilings, trapping occupants in their beds. The fire started when an elderly occupant while smoking accidentally ignited a curtain in his room.

A fire in Omaha, Nebraska, March 23, 1948, that took eight lives indicates that nursing home personnel are also guilty of careless smoking. Investigators concluded that the owner of this home followed his usual practice of going downstairs for a midnight snack, after which, on this par-

*See Sept. 1954 "Fire News," page 10 for article on ash trays (reprints, 5c each).

Gallagher Nursing Home; Billings, Montana, January 25, 1953.

ticular night, he lay down for a smoke on an overstuffed sofa in the front hall. He fell asleep. The fire had spread from the sofa up the open stairway to the second story before being noticed by a neighbor an hour and a half later.

Housekeeping

For lack of a better term "poor housekeeping" is used to describe a multitude of housekeeping sins that cause fires. Since most of these sins involve accumulations of rubbish and worthless materials of one sort or another, it follows that fires from this cause do not occur in clean and neat establishments.

It was not rubbish accumulation, but a form of poor housekeeping nonetheless, that caused a fatal fire in Hoquiam, Washington in 1951. Twenty-one aged men and women lost their lives. The fire was due to the careless practice of hanging sheets and blankets to dry above an incinerator in the first floor laundry roo Nothing happened until the next d when a maid emptied a wastebasket in the incinerator. Sparks ignited the shee and flames spread with sickening spe through an open laundry chute and up t only interior stairway, both of which te minated in the second story hallway. A outside stairway, the only other way ou was cut off because it was exposed b flames belching from a window in th laundry.

Fire Protection Features

When a fire occurs we can be pret sure that no casualties will result an property damage will be small if the fi is discovered and extinguished promptl A human nose is about as good a fire d tection device as you can find *if* its own is present and awake when the fire start and a glass of water is an excellent fi extinguisher *if* the fire is small enoug

when discovered. The "ifs," however, do not always describe actual conditions and it will be wise to supplement noses and water glasses with more reliable means of fire protection. Such protection is available in the form of automatic sprinklers, automatic fire alarm systems and approved fire extinguishers.

Sprinkler Systems

Arguments have been raised against sprinkler systems on the grounds that they are costly to install. It is true that a large investment is sometimes involved but it is also true that the dividends are very attractive. There is no denying the excellent protection afforded by these systems as substantiated by records of actual performance in fires. When installed to protect the entire building these systems largely counteract the fire hazards introduced by building construction, contents, habits of occupants and lack of other types of fire protection. A loss of life fire in a nursing home completely equipped with a sprinkler system has yet to be reported to the NFPA. This record is not due to chance, but to repeated performances such as occurred at the two following fires. In Somerville, Massachusetts, on September 26, 1952, firemen responded to a central-station-supervised sprinkler alarm to find that 10 sprinklers had practically extinguished two fires that had been set in clothing and mattresses stored in the attic of the 5-story home. And in Pasadena, California, on November 21, 1948, a nursing home was spared a serious fire and possible casualties when a sprinkler in a janitor's closet detected and extinguished fire in a trash barrel.

Automatic Detection Systems

An automatic fire alarm system is a much more reliable fire detector than the human nose provided it is an approved system, is installed to cover all parts of the building including basement, attic, closets and other out-of-the-way places and is properly maintained. These systems detect fires and give the alarm automatically and are not to be confused

Wide World

McClary Convalescent Home; Hoquiam, Washington, January 30, 1951.

Press Association

Catholic Home for the Aged; Garfield Heights, Ohio, February 2, 1946.

with alarm systems operated manually after the fire has been discovered. The records are filled with cases where lives could have been saved had some means been provided to detect the fire early enough that patients could be evacuated.

Fourteen occupants of a nursing home lost their lives in a fire at Garfield Heights, Ohio in 1946.* Looking at the building from the outside and noting that it was only one story high and had several wide exits, one might be excused for thinking that the occupants had nothing to fear from fire. A look inside, however, and the picture would change, since the large undivided attic, the highly combustible interior finish and the absence of automatic protection would suggest several ways in which fire could endanger its occupants. This tragic fire started in the attic and since there was no automatic means provided for discovering fire, developed unbeknownst to the occupant until it burst through the ceiling an flashed over the combustible interior Compare these results with the experienc of a nursing home at Charleston, Sout Carolina when a fuel oil fire occurred i the basement on April 26, 1952. The fir was almost immediately detected by a automatic fire alarm system that operate an alarm bell in the building and simul taneously transmitted the alarm to the fir department. Alerted by the alarm, age occupants filed from the building accord ing to a prearranged evacuation plan an firemen arrived to put out the fire wit a booster line.

*See April 1946 Quarterly for detailed report.

Fire Extinguishers

Approved type fire extinguishers hav put out a large number of small fires i nursing homes and are highly desirabl protection to have available. However, is important to remember that fire extin

guishers are worse than useless if the nursing home personnel do not know how to use them, and it should also be kept in mind that because of the limited amount of extinguishing agent in them, they are effective only on fires that are small when discovered.

On detecting a fire, good judgment is needed to decide whether the fire is small enough to be controlled by a fire extinguisher or whether help should be called at once and evacuation of occupants commenced. A fire in a Philadelphia nursing home was mentioned in which employees used twelve fire extinguishers before calling the fire department. To anyone with a knowledge of what a fire extinguisher can and cannot be expected to do, it would have been obvious that this was no fire for extinguishers and the fire department would have been called at once. Had this been done the fire undoubtedly could have been confined to the room of origin.

The adequacy of training in use of fire extinguishers shows up when a fire occurs. If the attendant has been shown how to use the device and has gained confidence in its effectiveness through actual use, the fire will usually be controlled without difficulty. When this training has not been thorough results are sometimes like those at the fatal nursing home fire in Colesville, Maryland in 1951. When discovered by two attendants, the fire was confined to a closet in one of the wards in the annex. The fire was then relatively small and good judgment should have suggested that one attendant give the alarm and start the prearranged evacuation program in motion while the other attacked the fire with an extinguisher. The alarm was given, and attendants commenced evacuation as instructed but no one thought to use any of the conveniently located fire extinguishers. During the 15 minutes required for the nearest volunteer fire department five miles away to assemble and get to the scene, the fire broke out of the closet, spread through the combustible annex and into the connecting main building. Most of the 50 occupants had been removed by the time firemen arrived but four died, one who could not be removed in time, two who went back into the building after being rescued, and one who, although rescued, later died from his injuries.

The reports of nursing home fires cited have served to indicate *what* factors are responsible for casualties and property damage in nursing homes and *how* these factors can be eliminated. Many more fires are on file that illustrate these fire safety weaknesses but the evidence already presented should be sufficient to show where attention should be focused. The 22 fires cited contained conclusive evidence that life safety of nursing homes can be materially improved by eliminating five notable fire protection weaknesses in the construction of the building, by taking certain steps to lower the fire hazards of the contents of the building, by initiating a fire safety program for the people in the building and by providing means for prompt discovery and control of any fire.

Eutectic Metals in Fire Protection*

By O. J. Seeds
Cerro de Pasco Corporation

It is not likely that many people besides those directly concerned with the manufacture, installation, inspection or maintenance of fire protection devices are aware of the presence and importance of the eutectic metals which guard our safety in numerous ways. These little watchmen (known as fusible plugs, sprinkler links, fire-door release links, fire detectors, and safety valves) are as dependable as human ingenuity can make them but are often taken for granted. Perhaps it would be valuable to understand these guardians by focusing some attention on the materials, manufacturing processes and controls which govern their reliability. Eutectic metals — what are they? What is the meaning of eutectic?

Perhaps the simplest definition of *eutectic* is the literal translation from the Greek which means *easily melted — of maximum fusibility.* To a metallurgist, an *eutectic alloy* is a *composition of two or more metals giving the lowest, or sharpest, melting temperature possible of any combination of said metals.* Non-eutectic alloys (off-eutectic alloys of the same combinations of metals) do not melt sharply; that is, they have a mealy, plastic, mushy or crystalline range between the solid and liquid states which is referred to as the melting *range.*

A well known example of an eutectic alloy is 61.9 per cent tin and 38.1 per cent lead. This alloy has a melting temperature of 361° F. An off-eutectic co position of the same two metals, 50 p cent tin, 50 per cent lead, has a melti range of 361°F - 421°F. This all called 50-50 solder, is fairly easy to ap in soldering because it is grainy a mushy enough to stay put, does not r off the work. To some extent, this fac of ease of handling governs the selecti of fusible alloys found in certain typ of fire protection devices, for example sprinkler links which require very ca ful soldering for assembly.

Eutectic Metals

The metals used in fusible alloys a bismuth, lead, tin, cadmium, indium, s ver and antimony and they are made in combinations of two or more. It of interest to note that an alloy of two more of these metals has a lower melti temperature than that of any of its co ponent metals. The majority of spr klers, fire-door release links, fusil plugs, or other devices operating bel 203°F, employ the four metal alloys bismuth, lead, tin and cadmium. D vices operating at higher temperatures u alloys of three metals or two meta These may be bismuth, lead, tin; bismu lead; or lead, tin. The last is gen ally known as solder — lead tin solde

Reliable performance of safety devi depends upon the uniformity of allo used and careful attention is paid to t details of compounding them. Wheth the alloy is made up by the manufactu of a given device or is purchased from supplier like Cerro de Pasco Corp., o

*Based on a talk by the author presented at the 58th NFPA Annual Meeting held May 17-21, 1954 in Washington, D. C.

virgin metals of a high standard of purity are used. The "Safety Relief Device Standards"* of the Compressed Gas Association specify: bismuth, technical grade, 98-99.5 per cent; lead, pure chemical, 99.99 per cent; tin, pure Straits, 99.+ per cent; cadmium 99.9 per cent.

After a fusible alloy composition has been adopted by a manufacturer, it is essential that this alloy does not vary from batch to batch, no matter how much time elapses between purchases. This unvarying uniformity of alloys is controlled by the use of pure metals, accurate weighing of metals in making up alloys, proper melting and mixing, observance of such details as thorough stirring before pouring into molds and the temperature at which pouring is done. Batches are sampled and checked against standards to assure uniformity before shipment. It is the practice to furnish whenever desired, a certificate giving the exact makeup by weights of components rather than by chemical determinations.

To indicate how precise fusible alloy compositions must be, many years ago when my company first began to supply bismuth metal to fusible link manufacturers, silver was present as an impurity. It was allowed to remain in the bismuth in trace amounts. Certain link manufacturers developed their products using this silver bearing bismuth. Years later, an improvement in our refining process completely eliminated the silver content. We naturally started to deliver this higher purity metal to customers without thinking it necessary to notify anyone of the change. In a very short time, complaints were received from link makers that their products were not testing properly. A study was made to determine the cause of complaints and it was found that absence of this fraction of a per cent of silver was responsible. Since then, this small but important quantity of silver, originally considered merely an impurity, has been added purposely when batches of fusible metals are made for the fusible elements of links of this type.

Testing Fusible Alloys

Each type of fusible device has a set of standards to which it must conform. Certain rigid test conditions set up by manufacturers' associations, the Underwriters' Laboratories and the Factory Mutual Engineering Division must be met by regular production products to obtain and retain approval of listing. A dependable method of testing fusible alloys is essential to assure that they are identical year in and year out. It is necessary to have a method for determining yield temperatures that gives completely reproducible results.

Yield Temperature Test

In the method employed by Cerro de Pasco a cast bar of the metal to be tested is used. This bar is 11/64 inches in diameter and 8 inches in length. Two pieces of this bar 2 inches long are placed on 2 parallel knife edges spaced 1 inch apart. Pieces are so placed that the ends overhang the knife edges by 1/2 inch. The supported samples are immersed in a glycerin bath not closer than 1/4 inch from the bottom of a beaker. This beaker is suspended in and controlled by an outer glycerin bath. Two thermometers are used, one in the inner bath with immersion bulb at the same level and close to the samples, the other in the outer

*Available from the Compressed Gas Association, 11 West 42nd St., New York, N. Y., Pamphlet S-1, 35 cents each.

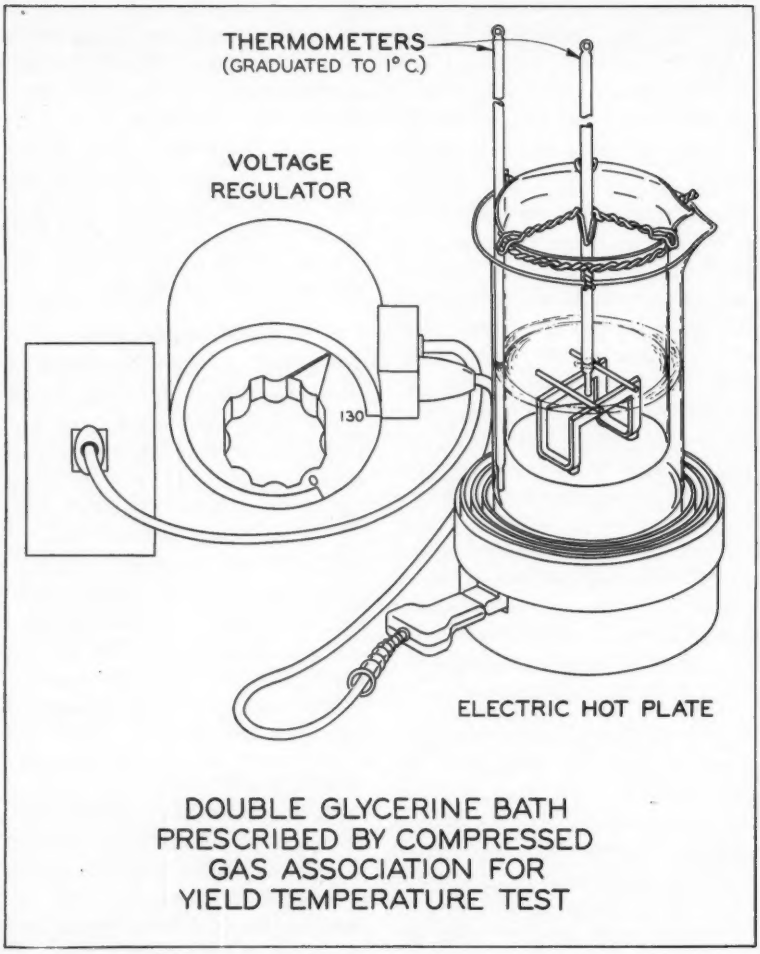


Figure No. 1.

bath. Heat is applied so as to maintain both baths at about the same temperature but the temperature of the inner bath is not permitted to rise faster than 5°F per minute. When the second of the four overhanging ends loses its rigidity and drops, the temperature of the inner bath is recorded as the yield temperature.

With the exception of the thermomete in the outer bath, this testing procedur is that prescribed by the CGA.

Freezing Range and Flow Point Test

In addition to this yield test anothe reliable and accurate test is made on fus ible alloys that also gives completely re

producible results. Four ounces of the alloy to be tested are melted and poured into an annealing cup. A short immersion bulb Centigrade thermometer is immersed in the molten alloy after it has been removed from the heat source. Temperature readings are taken every 30 seconds with continuous stirring. The temperature at which the first crystal appears is noted. As the temperature continues to fall and the alloy appears to be approaching the solidus, the annealing cup is tilted to an angle of 45 degrees. At this angle, the alloy, in its semi-molten state, will flow. When the metal no longer flows when thus tilted, the temperature is recorded as the flow point. This temperature, in almost all cases, coincides with the yield temperature determined by the Compressed Gas Association test and is thus a good cross check. The solidus is recorded as the temperature at which the point of a lead pencil can no longer be dented into the surface of the solidified metal. Temperature readings continue to be made until the alloy reaches room temperature.

The readings are plotted on a standard 20 x 20 graph paper with temperature readings on the ordinate and time readings on the abscissa. Hundreds of these freezing curves, or melting curves, have been accumulated during the many years that our company has been manufacturing low temperature melting alloys. These tests have proven to be extremely reliable and fully reproducible for the same compositions. Occasionally, unknown alloys are tested and after the curve has been plotted, it is compared with other curves until one is found that matches perfectly. The chemical analysis of the unknown proves out within a fraction of percent in most cases and thus this test is considered reliable enough to permit elimination of chemical analysis in many cases. The freezing range determination is simple, rapid and accurate, whereas the melting point determination is slow, requires elaborate apparatus and in general is not considered quite as accurate a method. The melting range curve usually gives slightly higher temperature readings at the main points.

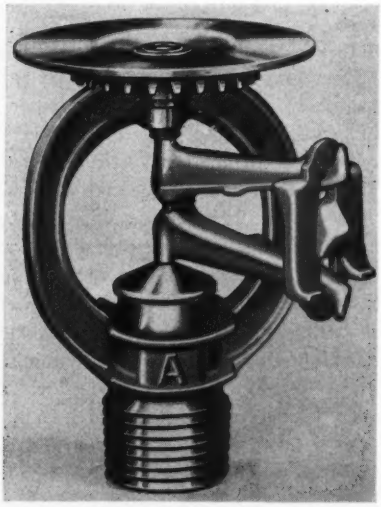
Nut Method

The Chlorine Institute has set up standards (known as the Nut Method) for valves and fuse plugs to be used in cylinders and containers for chlorine gas. The Institute prescribes definite compositions of bismuth, lead, tin, cadmium alloy, together with acceptable standards of purity of the components and a procedure to be followed in compounding as well as testing. This method is an equally reliable testing procedure for determining the melting point of a fusible alloy. A brass hex nut having a threaded 5/16 inch hole is filled with fusible alloy and allowed to solidify. The nut should be of ample size to provide adequate heat conductance to the fusible metal. Suitable dimensions are 1/2 inch thick and 5/8 inch across the flats. The fusible metal filled nut is suspended with the axis of the bore vertical in the center of a 2 liter beaker filled with water or glycerin and equipped with a mechanical stirrer to keep the water or glycerin temperature uniform throughout the bath. If water is used, it should be first boiled to eliminate dissolved air interference, due to gas bubbles clinging to the nut. The temperature is increased carefully to 155°F and then raised at a rate not to exceed 1°F each 3 minutes. Melting point is the temperature at which metal is first observed to sag from the hole in the nut.

Uses of Eutectic Metals

The types of devices using fusible metals for fire protection purposes fall mainly into three classes: links, plugs and fuses. Generally speaking, the links in common use are for sprinklers and fire-door releases.

Sprinkler Links

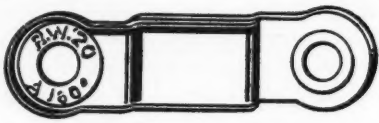


Courtesy "Automatic" Sprinkler Corp.

Figure No. 2. A modern spray sprinkler with a 165° fusible link.

These devices consist generally of an assembly of three pieces: two pieces comprise the body and the third piece the key. All three parts are carefully soldered together by an exacting soldering technique. These links are rated after testing to determine their yield or "let-go" temperatures. The link most commonly known (classified as "ordinary") and used in most occupancies is known as the 165° link. Others with higher ratings are known as the 212° link ("intermediate"), the 286° link ("hard"), and the 360° link ("extra hard").*

Door Closers



Courtesy Richards-Wilcox

Figure No. 3. A fusible link of the type listed by Underwriters' Laboratories for fire door hardware. Approved with 160°, 212°, 286° and 360° ratings.

Door-release links may form a part of a spring-loaded self-closing device or a part of a rope or chain over pulleys holding weights which keep a door on a slanting track in a normally open position.** In either case, if the link should "let-go," due to fire, the doors protected by them would positively close to carry out the function.

Plugs

Fusible plugs are made in many varieties and very definite specifications have been developed for their proper design and construction. In general, a fusible safety plug for a compressed gas tank will consist of a base of brass provided with pipe threads on the outside and a hexagonal section for wrenching. The inside may be a through hole having tapped threads; it may be tapered with the small diameter holes facing the atmosphere side, or it may be a step drilled hole, again with the small diameter facing atmosphere. This type of plug is generally used for gases of the low and medium pressure class.

For gases which are transported in containers under higher pressure, the

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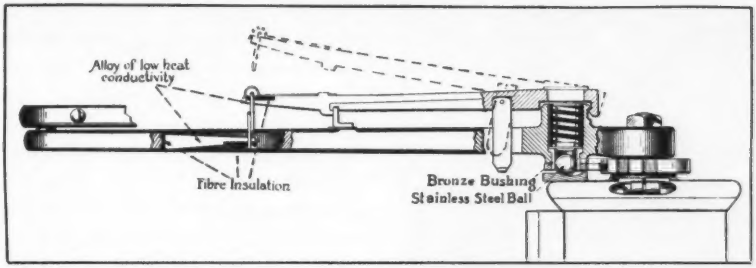
*See NFPA Standards for the Installation of Sprinkler Systems (NFPA No. 13), Par. 610.

**See NFPA Standards for Protection of Openings in Walls and Partitions (NFPA No. 80), Paragraph 410.

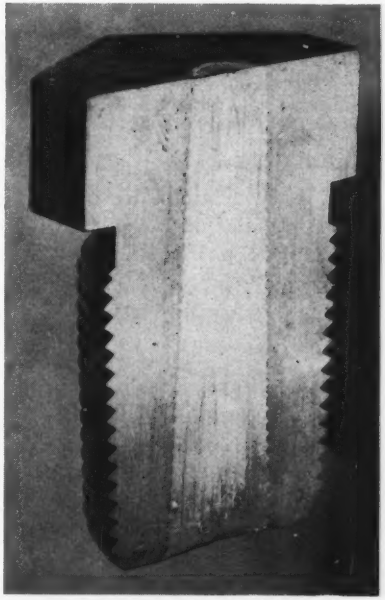


Courtesy P. & F. Corbin

Figure No. 4. This automatic fire door closing device employs a fusible link. The link is insulated from heavier metal parts and the arm insert which holds the link is made from the same metal and is further insulated with fibre where it joins the arm. Operation is effected when the link fuses which allows the lever to snap up and be disengaged at both ends (although held to the arm by the centralizing lever). Spring tension allows the ball shown to roll out of its slot allowing the door to close.

safety plugs are fitted with rupture discs in addition to the fusible alloy protection. The fusible alloy is always on the atmosphere side of the release device and serves to back-up the rupture disc so that under normal conditions, the combined strength of the alloy and the disc will withstand the pressure. If a fire should occur and the fusible alloy should melt, then the rupture disc is free to burst and release pressure.

We have mentioned that definite specifications or standards have been established for designing and testing links and plugs. This is also true of the method of loading fusible alloys into safety plugs and the kinds of fluxes which may be used. The manufacturers of these important safety devices insist upon using only thoroughly experienced personnel for soldering links and loading plugs.

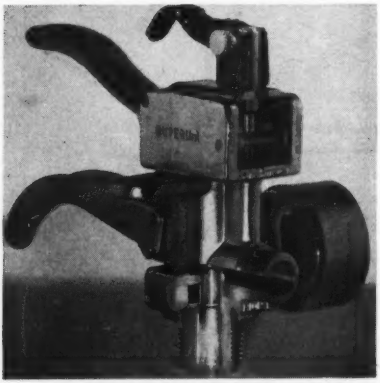


Courtesy Superior Valve & Fittings Co.

Figure No. 5. Three-quarter inch pipe thread fuse plug used in ton containers of chlorine and other high pressure gases. In service, pressure is at base of tapered section. Internal threads give additional bonding area to assist in supporting fuse metal column at 120°-130° ambient temperatures. Nominal melting temperature is 157°F.

Fuses

There are numerous types of fire alarms which employ low melting alloys for giving warnings or signals of fire. Again, reliability is highly essential. Fusible alloys in this use may consist of circuit links of a low melting alloy connected directly in an



Courtesy Superior Valve & Fittings Co.

Figure No. 6. Fire extinguisher valve made for a stored-pressure dry chemical extinguisher distributed by Safety First Products, Inc. Cutaway shows fusible safety plug which has melting temperature of 275°-290°F. Plug hole is tapped to provide ample bonding surface to support 425 pounds per square inch pressure in 200°F. ambient temperature without cold flow.

electric circuit. When broken, due to melting by the heat of a fire, an alarm is sounded. In other fire alarms, the fusible element may not carry current but be so arranged as to trigger spring-wound or compressed gas mechanisms to ring a bell or sound a horn.

Reliability of Fusible Alloys

It is a source of never ending wonder to those of us who are directly connected with the production of these safety devices that they function so reliably even after many years in service. I think the credit for this reliability is divided approximately one-third, or less, to the manufacturer of the fusible alloys and two-thirds, or more, to the people who assemble and test these metallic watchmen. It is an engineering feat to produce a small link which will support a dead load of 100 pounds or 150 pounds for a period of years, when the solder holding the parts together, if tested under such loading by itself, might break within a relatively short period of time. We know of sprinkler links, for example, which have been under a 100 pound load for as long as 30 years without breaking apart. It should be noted that it is just as essential that a sprinkler shall hold together under normal conditions as it is to break apart under fire conditions.

Mention should be made of a condition which may have a definite bearing on reliable performance of sprinklers under high temperature conditions. For instance, sprinklers rated at 360°F have failed to function at 400°F (or somewhat higher) after being in service at locations having 300°F temperatures over a long period of time. The question has been asked: "Why should this be the case when the solder used to make the original sprinkler assemblies was used to prepare fresh sprinklers which would function at 360°F?" It is our belief that the sprinklers which were subjected to 300°F temperature for long periods of time underwent a definite physical change. Since the alloy used to make the 360° link is high in tin, some of the tin content migrated into the base metal of the sprinkler. Also, some of the copper in the base part, which would be either brass or bronze, migrated into the lead, tin solder. In this way, a new alloy was formed at the interface. Said alloy would, naturally, have a higher melting temperature than that of the original solder. We are quite certain that this theory would be borne out by a chemical analysis of the interfacial layer.

Another interesting situation has been recently called to our attention. A fire extinguisher of the compressed gas type, having a fusible safety valve, intended to "let-go" at about 212°F, was put into

service in a diesel locomotive. After a short period of service in this abnormally hot location, it was discovered that the alloy had partially extruded from the safety plug, allowing leakage of gas. This rendered the extinguisher worthless. A photomicrograph revealed that eutectic melting had occurred. Eutectoid particles of the off-eutectic alloy used in this plug segregated from the other components which were in excess. Under the conditions of internal pressure and high ambient temperature, eutectic melting served as a lubricant to allow the center core of the plug to extrude. The condition was corrected by substituting a plug containing an alloy which was rated to "let-go" at 275°F. The purpose in citing this case is to point out that in selecting alloys for various safety purposes, it is important that all factors be considered, particularly the factor of ambient temperature at the location in which the device is to function.

There has not yet been any way devised to select a fusible alloy except by the trial and error method. For instance, an inventor may want to make a fire detection device. He decides that 160°F is the temperature at which he wants it to function. He may find there is an alloy which has a yield temperature of 160°F. He purchases a quantity and proceeds to test it. He is disappointed when the device does not "let-go" until ambient temperature goes a number of degrees above 160°F. Or, the reverse may be the case and the device goes off several degrees below 160°F. The best procedure to follow is to try out various samples of fusible alloys under actual working conditions and tabulate results. If none of the existing combinations is found satisfactory, new alloys should be tried until the desired composition is obtained.

Digest of Annual Meeting Discussion

Question: What deterioration takes place in the fusible alloys in sprinkler links over long periods of time? Is it advisable to replace sprinklers after a certain time?

Answer: It is not necessary to throw *all* sprinklers away after certain periods of service. Time and ambient temperatures are important factors. Prolonged 300°F exposure may result in solder in a link changing physically by migration of the tin into the base metal of the sprinkler and by migration of copper from the sprinkler base metal into the lead-tin solder. 360°F sprinklers might advisedly be changed for new ones after certain periods of time. In the case of softer links (165°, 212°F. and others) there is a much wider spread between the normal ambient temperature and the melting point of the tin (450°F.) in the solder. The Laboratories have not found deteriorations are as great in softer (low temperature) links as they are in the harder (high temperature) links.

Question: After a period of years, is there a chance that fusible metals in fire devices may deteriorate to the extent that the operating temperature of the fusible metal would be raised higher than when first made?

Answer: After a long period of time, this diffusion of tin will eventually take place. In the case of sprinklers, there is nothing to fear because links are dated and each year certain links are tested. If the links are found off-standard, they can be changed.

Question: Why are there no commercially available alloys between 621°F, the melting point of lead, and 1140°F, the threshold of the silver solders?

Answer: No one has found one which is satisfactory within that range.

Question: To what extent does the presence of flux have an effect on the flow point of a fusible alloy?

Answer: Flux has little or no effect on the flow temperature of the solder but does affect its wetting action.

Question: If there is oxidation, can this raise the temperature appreciably?

Answer: The oxidation is only on the surface. It may encase your alloy in a shell which may have some indirect effect on the melting point. One alloy, Bismuth-Lead eutectic (55½ per cent bismuth, 44½ per cent lead), is very subject to atmospheric oxidation and is not good for links.

What Causes Electrical Fires?

By Charles L. Smith
NFPA Electrical Field Engineer, and
E. C. Cogan
Assistant Technical Secretary
International Association of Electrical Inspectors

A total of 16,407 electrical fires were reported during 1953 to the International Association of Electrical Inspectors (IAEI) from 58 cities in the United States, Canada and Hawaii. A study of these fires shows that defective installation of electrical equipment was the leading known cause (14.95 per cent of all fires). Percentagewise this was a 187 per cent increase over the previous year in fires from this cause! Equipment which wore out in service was the second most frequent known cause (13.95 per cent of all fires). Table No. 1 lists the major fire causes.

Motor winding burnouts were a principal defect. Automatic fractional horsepower motors and domestic refrigerator motors were identified as being highly subject, but in over 1,800 such motor burnouts, the type of motor was not identified. In 1953, this origin jumped 3.4 percentage points over 1952's record. Heated appliances and incandescent lamps in contact with or too close to combustible material constituted the second most prevalent source of fires. Cords, particularly on circuit extensions, were third.

About 3.2 per cent of the fires originated in television receiving sets. Table No. 2 reports the important origins of these electrical fires and Table No. 3 gives a detailed tabulation indicating the specific types of electrical equipment involved.

The reports received by the IAEI from 58 cities were voluntary services by the electrical inspectors of the cities listed in Table No. 4. The report form used is reproduced on page 118. During 1953, fourteen more cities performed this service than in the previous year, indicating an increasing interest in analyzing the direct causes of fires originating from the misuse of electricity. Six years ago only 2 cities cooperated.

Greater participation among the 524 U. S. cities whose population exceeds 25,000 and among similar Canadian municipalities is greatly desired. This report contains conspicuous omissions in quantity of reported incidents and too many of the fires are listed "reported of electrical origin, no other details."

It is only through detailed study of every fire reported that intelligent measures can be taken to combat the menace of electrical misuse which today results in millions of dollars in fire damage, untold hardships and loss of life. The IAEI has published a "Manual for Investigating and Reporting Electrical Fires" to guide inspectors in making orderly, helpful studies on a uniform, international scale. The most compelling reason for these investigations is that through such studies changes may be made in the National Electrical Code which, when enforced, will correct fire hazardous conditions.

(Continued on page 116)

Table No. 1 — Standard Classification of Electrical Fire Causes

1953 Experience. Source: International Association of Electrical Inspectors

Cause of Fires	No. of Reported Fires	Per Cent of Total
(a) Defective installation	2,455	14.95%
(b) Worn out in service	2,289	13.95%
(c) Improper use of approved equipment	1,009	6.15%
(d) Accidental occurrence	1,067	6.50%
(e) Unknown or not reported	7,282	44.40%
Reported of electrical origin, no other details	2,305	14.05%
Total fires reported	16,407	100.00%

Notes to Table No. 1

The five standard classifications noted above (a, b, c, d, and e) are used to secure comparative results from all reporting agencies. The "Manual for Investigating and Reporting Electrical Fires" gives the following explanations for the five items:

(a) "Defective installations" means installations which are improperly installed or installed in a manner not acceptable by the National Electrical Code —i.e. a fractional horsepower motor automatically started which does not have overcurrent running protection as recommended by the Code.

(b) "Worn out in service" indicates equipment actually worn out in service or wires having served a full and useful purpose for a period of years which have deteriorated strictly from service thereby resulting in a fire.

(c) "Improper use of approved equipment" indicates that while the equipment itself complies with safety standards of recognized testing laboratories, fires have occurred because such equipment is used under conditions not covered by its approval—i.e. use of No. 16 lamp cord for extension lights in hazardous locations.

(d) "Accidental occurrence" implies fires caused by such occurrences as clothes left in contact with lamps, dropping materials into electrical equipment accidentally, heated appliances left on unintentionally, etc.

(e) "Unknown or not reported" should include only those fires of probable electrical origin wherein the evidence has been destroyed to such an extent that a cause cannot be assigned.

Table No. 2 — Standard Classifications of Fire Origins

1953 Experience. Source: International Association of Electrical Inspectors

Place of Fire Origin	No. of Reported Fires	Per Cent of Total
Origin due to motor winding burnouts	5,541	33.80%
Origin due to wires and cables	2,519	15.33%
Heated appliances and incandescent lamps left in circuit, unattended and in contact with or too close to combustible material	1,157	7.05%
Origin on cords	1,074	6.55%
Fixtures, outlets, sockets, receptacles	875	5.33%
Origin in TV receiving sets	526	3.21%
Origin due to transformer burnouts	242	1.48%
Signs	218	1.33%
Origin in radio receiving sets	163	0.99%
Cutout cabinets, control panels, boards	140	0.85%
Lightning	106	0.65%
Switches	59	0.36%
Origin in Christmas tree wiring	31	0.19%
Origin on or due to miscellaneous wires and devices	1,451	8.83%
Reported of electrical origin, no other details	2,305	14.05%
Total fires reported	16,407	100.00%

Table No. 3 — Detailed Tabulation of Fires of Electrical Origin

1953 Experience. Source: International Association of Electrical Inspectors

	Defective Installation (a)	Worn Out (b)	Improper Use (c)	Accidental (d)	Unknown (e)	No. of Fires
Appliances						
Irons in mercantile occupancies	0	2	7	1	0	1
Irons in residential occupancies	9	16	98	63	12	19
Misc. heated tools and appliances	119	45	60	31	65	32
Location not reported	2	0	21	78	444	54
Cable						
Armored	15	17	3	99	3	13
Elevator light or control	1	4	0	0	0	
Used on large portables	1	0	0	0	0	
Non-metallic sheathed	3	4	6	0	0	1
Range	4	10	0	2	0	1
Service entrance	11	42	10	0	1	6
Christmas tree wiring	7	3	14	0	7	3
Cords						
On miscellaneous appliances	56	40	17	7	9	12
On portable lamps	53	29	8	4	2	9
Circuit extensions	268	24	35	5	36	36
Type or cause not reported	205	14	2	1	259	48
Cutout Cabinets and Distribution Panels	42	17	28	4	21	11
Elevator Control Board	1	3	0	3	21	2
Fixtures						
Chain	44	5	111	14	3	17
Drop cord	17	23	1	2	3	4
Electric discharge lamps (under 1,000 volts)	55	49	14	3	18	13
Electric discharge lamps (over 1,000 volts)	1	0	0	0	0	
Miscellaneous type not reported	29	16	4	20	22	9
Lamps (incandescent)	8	13	30	14	19	8
Meters (defective)	3	26	0	2	17	4
Motion Picture Projectors	0	0	0	0	0	
Motors (Winding Burnouts)						
Domestic refrigeration	100	421	29	88	1,460	2,09
Fractional HP automatic control	165	434	146	47	124	91
1 HP and over automatic control	12	46	8	7	23	9
Manual control	30	39	10	3	500	58
On elevators	10	7	1	1	30	4
Load not reported	56	310	162	11	1,261	1,80
Outlets						
For fixtures and junctions	138	52	13	19	9	23
Miscellaneous	8	6	1	3	55	7
Radio Receiving Sets	16	20	2	8	117	16
Receptacles	11	17	1	19	38	8

Table No. 3. Detailed Tabulation of Fires of Electrical Origin (Con't)

	Defective Installation (a)	Worn Out (b)	Improper Use (c)	Accidental (d)	Unknown (e)	No. of Fires
Signs						
Neon (inside)	6	6	1	4	1	18
Neon (outside)	47	48	11	26	15	147
Location not reported	1	3	0	4	45	53
Sockets						
Incandescent lamps	8	5	11	3	0	27
Electric discharge	0	4	0	0	0	4
Sparks						
Motor brushes	12	1	4	11	3	31
Static	0	5	11	7	2	25
Welders	5	0	5	5	5	20
Toy trains	0	0	0	0	0	0
Switches						
In canopies of fixtures	4	1	0	0	0	5
In gasoline pumps	0	0	0	2	7	9
Miscellaneous	3	15	4	2	21	45
Television Receiving Sets	33	130	6	40	317	526
Transformers						
Neon sign (portable)	14	36	0	0	0	50
Neon sign (not portable)	8	12	0	1	4	25
Low voltage	14	4	0	3	46	67
High voltage other than neon	2	5	0	8	65	80
Voltage not reported	0	0	0	0	20	20
Wires						
In rigid conduits (inside)	15	10	3	19	2	49
In rigid conduits (service)	10	20	4	3	3	40
Bell	1	1	0	1	0	3
Signal systems	1	9	3	10	1	24
Telephone	0	0	0	0	1	1
In gasoline pumps	7	0	0	0	0	7
Service drops	3	1	46	15	26	91
Overhead wires	9	19	0	16	26	70
Miscellaneous	250	33	48	210	1,457	1,998
Miscellaneous equipment other than wires	502	167	10	12	636	1,327
Lightning	0	0	0	106	0	106
Reported Electrical Origin (no other details)	0	0	0	0	0	2,305
Total Fires Reported	2,455	2,289	1,009	1,067	7,282	16,407

Electrocutions: 3

Table No. 4

Cities Voluntarily Cooperating in Electrical Fire Reporting Service

Sponsored by International Association of Electrical Inspectors

Albuquerque, New Mexico
Alhambra, California
Ann Arbor, Michigan
Atlanta, Georgia
Bismarck, North Dakota
Boise, Idaho
Boston, Massachusetts
Canton, Ohio
Chicago, Illinois
Cincinnati, Ohio
Cleveland, Ohio
Compton, California
Dayton, Ohio
Dearborn, Michigan
Des Moines, Iowa
Detroit, Michigan
Duluth, Minnesota
Eugene, Oregon
Flint, Michigan
Fresno, California
Grand Rapids, Michigan
Great Falls, Montana
Houston, Texas
Indianapolis, Indiana
Jacksonville, Florida
Kansas City, Missouri
Lansing, Michigan
Lincoln, Nebraska
Lodi, California
Long Beach, California
Los Angeles, California
Miami, Florida
Milwaukee, Wisconsin
Minneapolis, Minnesota
Montreal, Quebec
New York City, New York
Oakland, California
Olympia, Washington
Oxnard, California
Philadelphia, Pennsylvania
Phoenix, Arizona
Portland, Oregon
Redwood City, California
Reno, Nevada
Richmond, Virginia
Saginaw, Michigan
St. Louis, Missouri
San Bernadino, California
San Francisco, California
San Leandro, California
Santa Barbara, California
Spokane, Washington
Stockton, California
Territory of Hawaii
Trenton, New Jersey
Tucson, Arizona
Vancouver, British Columbia
Washington, D. C.

Other inspection authorities, including fire departments, fire marshals, government bureaus and insurance inspectors can cooperate in this program. Reproduced below are pertinent sections of the instructions given in the IAEI Manual.

Standard Reporting Methods

An electrical fire is an instance of destructive burning where the origin of ignition was due to heat from an electrical source.

Small fires are just as important as large ones. It is from the latter that the best data is available on how fires originate.

Regardless of reported origin, all fires which occur within buildings that contain electrical wiring should be investigated by an electrical inspector to ascertain if the cause of the fire was electrical or if any wires were damaged by the fire. Notices of fires may be obtained from fire departments where such departments were called to extinguish the fire. The cause of the fire in many of these notices will be found in error or incorrectly stated. Cases reported as "unknown" will frequently be found to be of electrical origin. Some of those blamed on electricity will be found to be from other causes. There are many fires, however, that are extinguished by others or burn out of themselves. Notice of these involving electrical equipment are usually obtainable from electrical contractors who are called upon to make repairs. Many municipal inspection departments do not permit repairs to electrical wiring damaged by fire, until an inspector has visited the scene of the fire.

The value of actual experience in investigating fires as an aid in determining the cause of fires cannot be over-estimated. Instructions, no

matter how detailed, cannot replace experience. In large inspection organizations, the investigation of fires reported as of electrical origin should be made by one or two men. In a city of a size warranting the employment of 50 electrical inspectors, there may be reported between 1,000 and 2,000 fires per year of electrical origin. If these were investigated by the inspectors in whose district they happened to occur and if they were divided evenly, each inspector would have the experience of investigating only about 20 fires per year. However, if such investigations are made by one inspector he would have the experience of the greater number and would, as a result, be a much more competent investigator.

It is the lack of personal investigation that has resulted in a lack of appreciation by many electrical inspectors of the number of fires probably due to electrical origin. It is certain, on the other hand, that an electrical inspector is familiar with the electrical conditions which cause fires. By being at the scene of a fire shortly after its occurrence, an electrical inspector is in the best position and is the most competent person to make a statement as to whether the fire was of electrical origin, excepting, of course, those instances where there were one or more competent eye witnesses.

Evidence Often Circumstantial

The character of the evidence in determining the cause of a fire will be circumstantial in many cases. A cause, however, must be determined or a remedy cannot be suggested. If we are to assign a cause to more than a fraction of the actual number of fires that occur, we must accept as the origin the most probable action or condition existing at the time and place. If two or more actions or conditions are equally probable, then, the cause must be reported as unknown. It follows, therefore, that the investigator should have some knowledge of the probability of all actions or conditions, whether electrical or otherwise, which do cause the majority of fires in any particular location. One method of investigation, where the cause is not clearly apparent, is by a process of elimination. Probable causes are accepted or discarded by evidence shown by the conditions until the most probable one is found.

It may seem inconsistent for engineers accustomed to dealing with proven facts to accept a "most probable" cause. However, there are very good reasons why such reports are of value.

In all except a very few fires, the cause could not be *proven* by the investigator. In only a few cases would there be eye witnesses whose statements could be corroborated. Therefore, in only a very small number of cases could the person making a report on the cause of a fire make his statements as an absolute fact.

There are many electrical actions and conditions which have caused fires. Where any one of these, or others that may be added, are reported many times by trained investigators working in various sections of the country and using a standard method of reporting and classifying causes, facts as to the probability of such actions or conditions starting fires are established. There will certainly be errors in some reports, but the majority will be correct and a few errors will not affect the final analysis.

Importance of Investigations

Any action taken to prevent fires of electrical origin, whether by changes in the National Electrical Code or publicity, will be governed by the number of fires or accidents reported. The number of such fires will also indicate whether the cost to the public, or to the electrical industry, in Code changes or publicity, is justified. It is very probable that information will be obtained that will warrant as many reductions as increases in the Code with a net result of a better Code.

The occupancy and the condition existing in the location in which a fire originated are important factors in determining the cause of any fire where the evidence is not conclusive.

There will be cases where the evidence of origin has been destroyed by the fire, removed or partly removed before the arrival of the investigator. In other instances the probability of electrical and non-electrical origin will be equal. Many of these must be reported as unknown.

Evidence of origin may be obtained by questioning persons who were in a position to know and were familiar with the conditions previous to and at the time the fire occurred.

Information on the actions or conditions which result in fires can be best obtained by study of the reports of fires as published by city fire prevention bureaus, the NFPA and insurance company statistical departments.

These reports list fires by types of buildings, occupancies, manufacturing processes and causes in the order of frequency of occurrence

ELECTRICAL FIRE REPORT

The following report form is prepared for use by fire chiefs when reporting electrical fires, as well as deaths or injuries that may be attributed to electricity. The International Association of Electrical Inspectors desires this information in order to secure an accurate record of fire causes that may be due to unauthorized installation, but lack of proper inspection, substandard wiring and equipment as well as causes attributed to carelessness. Where the story of the fire is intended to be more complete, use the the blank side of this report.

Report sent by _____
Title and Name

Address _____

Date of fire _____ Where did fire originate? _____

1. Was fire confined to source? _____
2. Type of building _____
3. Loss on equipment _____
4. Loss on contents _____
5. If fire was due to failure to disconnect electrical appliance, state the type _____
6. If faulty flexible cords contributed to the cause of fire, state the type of appliance used _____
7. Was fire due to illegally extended lighting circuits? _____
8. Give all facts as to motor fires such as name, type, horsepower, volts, mechanical load as well as automatic protection, if any _____
9. What is the proper classification of this fire? _____
10. What in your opinion caused the fire? _____
11. State the kind of business activity or process conducted in the particular part of the building where the fire originated _____
12. Are the premises inadequately wired? _____
13. Were all the fuses in good order and of the proper size? _____
14. Were any lives involved or injuries received as directly attributed to electricity? If so, give all the details. Use reverse side.
15. How can members of our organization assist your department with your electrical problems. State on reverse side.

Signed _____

Figure 1

and amount of loss. The importance of the knowledge to be gained by a study of these reports to an investigator cannot be over-emphasized.

Classifying the Causes of Electrical Fires

Many inspectors state the cause of an electrical fire as a motor, defective wiring, a short circuit, etc. In some cases with these wordings, together with the name of the electrical equipment involved and the location, a fair idea of the manner in which the fire occurred might be obtained. In the majority of cases such wordings do not give useful information nor fully describe the conditions.

One of the principal objects of the Standard Electrical Fire Report Form (See Figure 1) is to make the reports of investigators in various sections of the country uniform so that the number of electrical fires of each type may be compared. It is obvious that wording of the various causes must therefore be standardized because very few persons would report the same type fire alike.

The ignition of combustible materials by or through the use of electric current results from excessive heat due to one of the following actions or conditions:

(a) Defective installation
(b) Worn out in service
(c) Improper use of approved equipment
(d) Accidental occurrence
(e) Unknown or not reported

All electrical fires could be broadly classifie under the above headings. For explanations these headings, see footnotes to Table 1.

When an investigator has determined that fire was of electrical origin a report should b made on the standard Electrical Fire Repo Form (see Figure 1). The forms may be ob tained from the Secretary of the Internationa Association of Electrical Inspectors, 612 Nort Michigan Avenue, Chicago, Illinois.

Notes on Use of Electrical Fire Report Form

For the most part, the individual items on th form are self-explanatory. The following note are designed to give added information on th proper use of the form.

Item 2. Give brief description of buildin construction, i.e. fire resistive, noncombu tible, wood frame, brick wood-joist, etc.

Items 3 & 4. A rough calculation of dolla loss is desirable to classify seriousness o resulting fire.

Item 5. If a considerable percentage of ele trical fires are caused by failure to disco nect, the industry wants to know this fa for safety education.

Item 6. Completion of this item will dete mine what appliances are most likely t have faults in flexible cords which, i turn, can lead to improving design an quality of the equipment.

Item 7. Training and educational program can be based on answers to this question.

Item 8. Increasing losses from motor wind ing burnouts make it important to get a complete answers to this question as pos sible.

Item 9. This refers to the five classification given in Table No. 1. Inspector shoul indicate by (a), (b), (c), (d) or (e) o by writing out cause as follows:

(a) Defective installation
(b) Worn out in service
(c) Improper use of approved equip ment
(d) Accidental occurrence
(e) Unknown or not reported.

Foam Rubber and Cotton Mattresses

By Louis Segal, Chemist
Office of the State Fire Marshal, State of California

Two more or less distinct aspects of flammability are involved in evaluating the fire hazard characteristics of mattress materials. One relates to fire fighting problems which the burning material presents. The other is concerned with the potential life hazard to the user.

From the fireman's point of view, the following burning qualities of cotton and foam rubber are of interest. A foam rubber mattress burns faster and hotter than does one of cotton, and, therefore, is somewhat more difficult to extinguish, with more water being required. Burning rubber emits dense, sooty, black smoke in large quantities. It has a very obnoxious odor. Burning rubber melts and drips and is extremely sticky. Foam rubber, on the other hand, does not smolder and, therefore, is not subject to re-kindling as is the case with cotton. These qualities indicate that foam rubber may be considered somewhat more hazardous than cotton insofar as suppression and extinguishment of mattress fires may be concerned. However, the Office of the California State Fire Marshal feels this is a relatively minor consideration as compared to the second aspect of flammability, the potential life hazard.

The potential life hazard of a mattress can appropriately be measured only in relationship to the hazard from a burning cigarette, which is, without doubt, the source of ignition in practically all mattress fires. Therefore, the question should be: "What is the likelihood of a burning cigarette starting a fire in this type mattress?" rather than, "How flammable is this mattress?"

Some years ago, this Office conducted tests which proved to our satisfaction that foam rubber itself could not be ignited by a burning cigarette.* This is because (1) the heat from a burning cigarette is not sufficient to ignite foam rubber, and (2) foam rubber will not support flameless combustion. The latter fact is of great significance since, with practically all fires started by cigarettes, flaming must be preceded by glowing. It follows, therefore, that flaming combustion of foam rubber mattresses will occur only as the result of flaming of the bedding above the mattress. On the basis of these facts, the question may be further modified to read, "Will cigarettes start fires in bedding, and if so, under what conditions?" It was with these considerations in mind that our tests were conducted.

Hazard of Smoking in Bed

When a person drops a burning cigarette in bed, whether or not a fire occurs will depend on many variable factors, including the following:

(1) The Cigarette — its length determines how long it will burn.

*See October 1952 Quarterly, page 134, for article on "Foam Rubber in Consumer Products."

(2) The Mattress—type of cotton; solid or innerspring; type of rubber; type of ticking.

(3) The Bedding—type and number of sheets and blankets.

(a) Dryness of Bedding—this is influenced by the temperature and humidity at the time of and preceding the incident.

(b) Arrangement of Bedding—number of folds, degree of bunching.

(4) Draft — number of open windows and doors, and location with relation to bed; amount of wind.

Test Materials

Obviously, the variety of conditions which can exist is infinite. In order to eliminate some of the variables for comparative tests, two of the above factors were fixed at the level of *maximum* hazard. First, a king size premium brand cigarette without tip was selected which was used immediately after lighting, thereby giving the greatest possible duration of burning time. Second, the bedding was oven-dried before each experiment. These conditions must be considered very favorable to combustion and considerably more severe than those which would normally exist.

The foam rubber used in the tests was made from pure natural latex and may be considered representative of the great majority of such material being used for mattresses today. Some foam contains a small percentage of synthetic GR-S, which makes little if any difference in the product's burning qualities. Also, there are foam rubbers made from chlorinated synthetic latex (such as Neoprene) which do not support combustion. These are somewhat more expensive than the natural foam, and until recently ha been in short supply, with most prod tion being taken by the armed forc However, increased production has n made ample quantities of these synthe latex type foam rubber mattresses av able for general use.

The cotton mattress used was of solid, institution type, covered with sta ard 8-ounce ticking. Sheets were typi cotton muslin weighing about 4 oun per square yard and blanketing was w weighing about 14 ounces per squ yard.

Test Methods

Approximately 100 tests were p formed in which lighted cigarettes w laid on many different combinations a arrangements of sheets, blankets, a mattress samples. For most tests, nor air circulation with only slight draft p vailed, while in some cases a 2-3 m per-hour wind from a fan was direc over the materials. Some of the arran ments were as follows:

(1) Mattress (with ticking) onl

(2) Mattress plus from one to tw ty layers of sheet, some plus blanket, flat.

(3) Mattress plus various quanti of sheet and blanket loosely bunched piled into assorted shapes.

(4) A few tests as in (2) and (above, with the addition of one layer twelve-gauge flame-resistant vinyl pla film over the ticking.

"Cigs" Ignite Cotton Mattresses

The first tests confirmed earlier fi ings, namely, that a burning cigar merely melts foam rubber and will initiate glowing or flaming. On

other hand, a moment's exposure of a cotton mattress to a burning cigarette will start it glowing. Once thus started, the flameless combustion progresses rapidly. For example, a cigarette was placed on a piece of cotton mattress for 5 minutes, then removed. By this time, the cotton was smoldering vigorously. At 10 minutes, the glowing area was 2 inches in diameter and ½ inch deep; at 20 minutes, 5 inches in diameter and 1¾ inches deep; at 30 minutes, 8 inches in diameter and 2½ inches deep. The temperature of this area ranged from 750°F. at the top center to over 900°F. at the bottom and sides where there was active glowing. Actual flaming might have occurred spontaneously at any time, and was readily initiated at will by blowing over the area for a few seconds. No additional tests were conducted over cotton mattresses, it being evident that this same result would occur whenever any glowing reached the ticking.

The remaining tests were directed towards learning what combinations and arrangements of bedding above the mattress might be susceptible to progressive glowing combustion and subsequent flaming. The important factor in this respect is whether or not the glowing initiated by a cigarette will spread appreciably beyond the point of ignition and will become self-sustaining. Actually, the mechanism of this phenomenon resembles very closely that of spontaneous heating, and it is most fortunate that conditions within which the action will take place are quite limited.

Summary of Test Findings

Following is a general summary of the results of 100 tests under various conditions:

(1) In only four instances did progressive, self-sustained glowing occur in the bedding materials above the mattress.

(a) Twenty layers of cotton sheet, 2-3 mile-per-hour wind, vigorous sustained glowing—burst into flame at 18 minutes.

(b) Cotton chenille bedspread, loosely bunched, normal air circulation — no flaming after one hour, extinguished.

(c) Cigarette between two flat sheets, 2-3 mile-per-hour wind, glowing initiated in ticking which continued after the fan was turned off — no flaming after one hour, extinguished.

(d) Four 12 inch square pieces of cotton sheet loosely bunched into a mass approximately 6 inches in diameter and 4 inches high — at 15 minutes the entire interior of the mass was glowing vigorously, and flaming occurred spontaneously at 22 minutes. This was the only instance where flaming occurred without artificial draft.

(2) In the great majority of the other tests, glowing progressed downward through the ticking, with little or no subsequent spread in either the bedding or ticking. Over foam rubber, the only effect was the melting of a small area.

(3) In the few tests with a layer of plastic film over the ticking, it was evident that under borderline conditions the plastic would absorb enough heat to prevent transmission of glow to the ticking. In many cases, however, the film was burned through and exerted little, if any, effect.

(4) The wool blanket showed little if any tendency to glow, but did not in most cases prevent cigarettes from burn-

ing through and initiating glowing in the bedding beneath.

(5) The intensity and rate of spread of glow was greatly increased by blowing on or fanning the involved area, due to the added supply of oxygen. Appreciable draft also was the most important factor in determining whether or not flaming occurred.

Conclusion

On the basis of these and previous related tests by this Office, the following conclusions are justified:

(1) Certain narrowly limited conditions must exist in order for a burning cigarette to initiate *flaming* combustion in the bedding on top of a mattress and the chance occurrence of such conditions would be very rare.

(2) A glowing cigarette or *glowing* combustion in bedding usually will reach the mattress. If it is foam rubber, the only result will be melting of the rubber. If it is cotton, the glowing will be transmitted to it and will spread, and in most cases the mattress eventually will burst into flames.

(3) Self-sustained glowing (with eventual flaming) is much more likely to occur with many layers of cotton sheet and blanket than with one or two; with loosely bunched masses of bedding than with the same material in flat layers; with cotton blankets than with wool; and with considerable draft than with still air.

(4) The use of a non-flammable plastic sheet over a mattress for purposes of sanitation may under certain conditions serve as a barrier to the spread of glow.

An additional factor not directly r lated to flammability should be co sidered in evaluating the potential li hazard of the cotton mattress. Smolde ing or glowing is incomplete or impe fect combustion which produces a gre deal of smoke containing a high pe centage of poisonous carbon monoxid plus other products of combustion, i cluding carbon dioxide. This is an esp cially dangerous combination. Carbo dioxide acts to stimulate the rate breathing, thereby increasing the amou of carbon monoxide taken into the lung The normal sleeping person exposed such conditions frequently will succum to the initial intoxicating or asphyxiatin effect of the carbon monoxide, and wi not awaken.

The person sleeping under the in fluence of alcohol or drugs is even mo vulnerable. Under such conditions, th victim is first rendered unconscious b breathing the poisonous combustion gase and death can then result from suffoca tion or carbon monoxide poisoning, the effects of heat. It seems reasonabl to assume that this hazard would b sharply reduced in the case of the foa rubber mattress, where glowing combus tion can take place only in the beddin and not in the mattress itself.

In summary, it is the opinion of thi Office that while foam rubber mattresse are somewhat more flammable than cot ton once ignited, they are much les likely to become ignited by the action o a burning cigarette. Therefore, the over all potential fire hazard of foam rubbe mattresses certainly is not higher tha that of cotton, and probably is consider ably lower.

Fire Hazards of Building Boards*

By D. Hird and C. F. Fischl

British Joint Fire Research Organization, Department of Scientific and Industrial Research and Fire Offices' Committee

When used in certain ways some kinds of building boards can contribute to the rapid spread of fire in buildings. In view of the importance of these materials to the building industry, it is essential to know where they may be used with safety. This report describes the results of experiments to show how common types of board might be expected to behave in actual fires.

In recent years there has been a growing tendency to avoid the use of plaster on walls and ceilings and to use instead, as internal linings, ready made sheets of materials which are included under the general term, "building boards." Although boards of the laminated fibre wallboard type were produced as far back as 1898, it was during and after the last war that the big increase occurred. Among their advantages are the possibility of production in large standardized sheets and ease of handling which facilitates speedy erection and repair. Certain types provide good thermal insulation and sound absorption.

Some building boards present an outstanding fire hazard since they permit extremely rapid growth of fire, particularly in the early stages. It is, therefore, necessary to have practical means of determining the fire hazard of different kinds of board accurately and of assessing the value of flame-retardant treatments so as to determine where they may be used with safety.

Ignition by Small Heat Sources

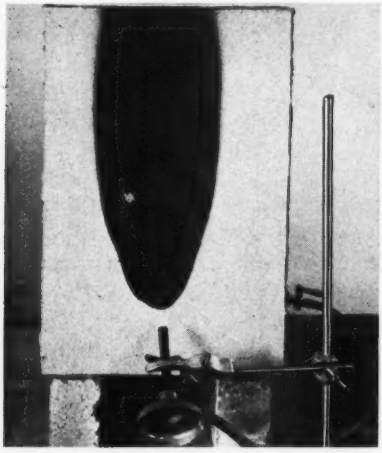
The most hazardous building boards are those which can be ignited by a small source of heat, and will give rise to a continuing fire. To investigate this hazard samples of board each 1 ft. by 1½ ft. were mounted vertically and a non-luminous bunsen flame played on the lower part of the sample. With untreated fibre insulating board and hardboard a self-propagating fire was easily started on all samples. It was found, however, that even a single coat of an oil-bound water paint or whitewash was sufficient to limit the flame spread to the area of flame contact (Figure No. 1).

Growth of Fire in Rooms

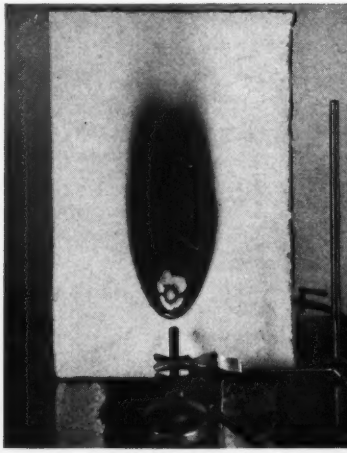
In the past many experiments have been carried out to observe the development of fire in average-sized living-rooms furnished in a standard manner. In 1949 an experiment was carried out to compare the development of fire in two houses, both of which were lined with fibre insulating board, but one having an additional layer of plasterboard fixed to it.† The surfaces of the walls of both houses were covered with

*Reprinted by permission of the Comptroller of Her Brittanic Majesty's Stationery Office from National Building Studies, Special Report No. 22. Full report available in the United States from British Information Services, 30 Rockefeller Plaza, New York 20, N. Y. for 40 cents.

†See January 1952 NFPA Quarterly, pages 218-224.



Spread on untreated fibre insulating board.



Spread on fibre insulating board coat with oil-bound water paint.

FIGURE NO. 1. SPREAD OF FIRE FROM SMALL SOURCE.

two coats of oil-bound water paint. The essential characteristic of the fire was that it started in the contents of the room, and the furniture was arranged in such a way that there was the high probability that, once started, a fire would develop to involve all the furniture. The aim of the experiment was to compare the contribution made by the wall linings to the rate of development of a fire.

Since 1949 a large number of experiments have been made with replicas of the living-room in the full-scale house on one-tenth, one-fifth and half scale. The room was furnished as shown in Fig. 2. Following the indications of preliminary tests, the dimensions of the room and its components were scaled linearly, except that the thickness of the timber was, whenever possible, constant for all scales. Thus the floor was of seven-eighth inch deal, the wall linings were of full thickness, and the wood used for the table was one inch.

Table 1 gives the range of ti taken for the whole room to bec involved for both full scale and mo for the three types of structure which full-scale results are availa Fig. 3 gives comparative tempera records for four of these tests.

It was considered from this evid that the growth of fire could be sim ted sufficiently accurately by the us small-scale models to justify the us this method in a comparative study the fire behavior of building boards.

Effect of Linings on Fire Sprea

The manner in which developmen fire is influenced by the lining of room is of considerable interest. all the experiments the fire was sta between the cupboard and the chai indicated in Fig. 2. The mutual sup given by the flames from these two pi of furniture was sufficient to ensure development of a substantial fire, respective of the surroundings.

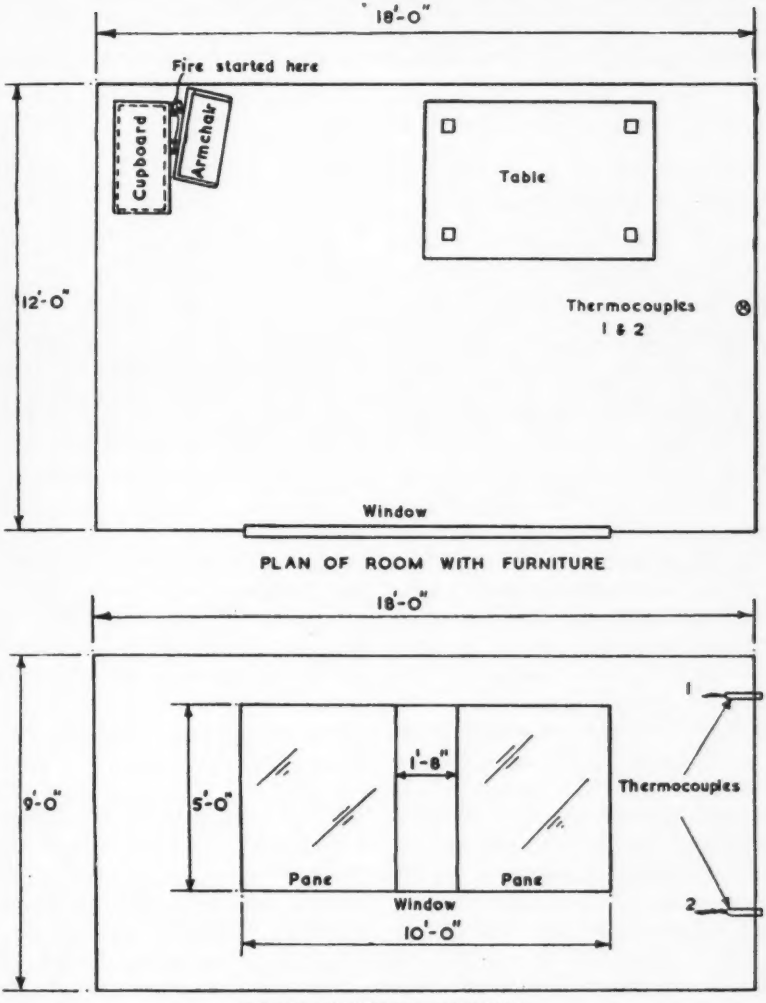


Figure No. 2. Diagram of Scale Room Used in Tests.

In the room with the noncombustible walls and ceilings the flames spread on the floor, assisted by radiation from the burning cupboard, until the table was involved. When the fire was well established in the table it spread quickly over the rest of the room, giving the condition known as "flash-over," illustrated in Figure 4 (last sequence), page 128.

In the rooms lined with building boards on wall and ceiling, once the flames from the cupboard reached the

Table I

Time Taken for Fire to Involve Whole Room—Both Full Scale and Mode

Type of structure	Time taken for fire to involve the whole roo	
	Full scale minutes	Mod min
Noncombustible walls and ceiling	14-20	15-
Fibre insulating board walls and ceiling with two coats of oil-bound water paint	5	5
Plasterboard walls and ceiling	23*	14-

*Under exactly similar conditions the plasterboard room could not take longer than the room with the non-combustible walls and ceiling, since the paper facing of the plasterboard would make some contribution. The probable reason for longer time taken by the full-scale plas board structure was that the ventilation more restricted than with the non-c bustible structure.

ceiling, the fire developed in an entirely different manner. With untreated fibre insulating board or compressed straw slabs, the ceiling was ignited almost immediately and the flames spread rapidly across the ceiling and down the walls, igniting the furniture before the flames had begun to spread along the floor from the cupboard. Figure 5, page 129, illustrates this in a one-fifth scale room.

In the rooms lined with treated fibre insulating board there were slight differences depending upon the treatments used. With silicate paint, the covering cracked very quickly and the protection offered under these circumstances was small. With surface and impregnation treatments on fibre insulating board (achieving higher ratings in the surface spread of flame test of British Standard No. 476*), the development of the fire was retarded until the fire in the cupboard was well established.

Once this occurred flammable gases were given off from the protected lining in sufficient quantities to accelerate spread of fire in the room. The mech ism from this point was similar to t in the rooms lined with the untrea board. This can be seen in Figure 6, pa 130, which shows the development of in a room lined with fibre insulati board with a flame-retardant surface tre ment applied.

The only exception to this method development with treated fibre insul ing board, was in the tests in which board was protected by a three-sixtee inch skim plaster coat. In these te the development was similar to that the room with the noncombustible wa and ceiling. The plaster formed impermeable covering and although so cracks appeared in it, flammable ga were not given off through these cra in sufficient quantities to affect development of the fire. The adhesi of the plaster appeared to be good, si none fell until some time after "fla over" in the room.

With the impregnated and surf treated hardboards and with plas board linings the mechanism of devel

*Available from British Standards Institution, 24 Victoria St., London, S.W.1, 4 shillings per copy.

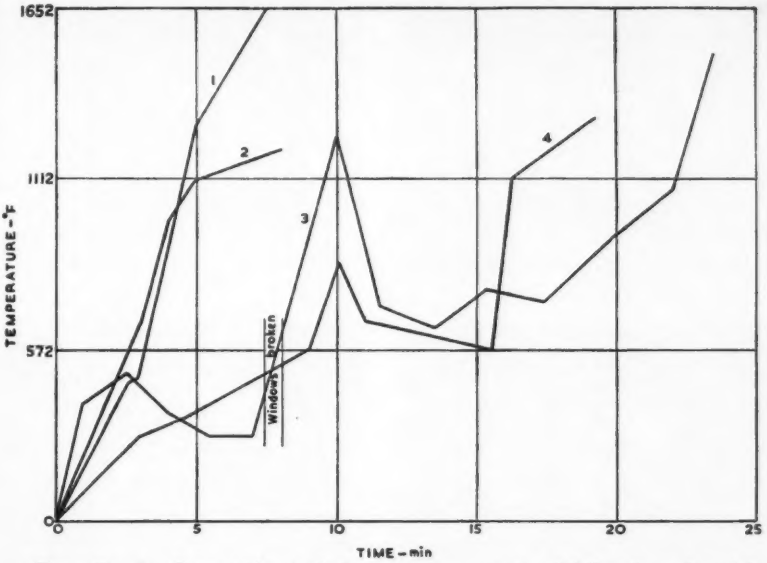


Figure No. 3. Comparative typical temperature records of full-scale and model rooms. Line 1 shows temperatures in a test in a full-scale room lined with fibre insulating board with two coats of oil-bound water paint. Line 2 shows similar data in a test in a model room lined with fibre insulating board with two coats of oil-bound water paint. Line 3 represents a test in a full-scale room lined with plasterboard and Line 4 a model room with plasterboard.

ment was again more like that in the non-combustible room, although there was some contribution from the boards in all three cases, there being most from the hardboard with a surface treatment.

The time taken for the whole room to become involved in fire when lined with various types of boards is given in Table 2, page 130. These results are the averages of at least three tests in each case, the maximum deviation from the mean being about 10 per cent. A selection of temperature records is shown in Figure 7, page 131.

Some tests were also carried out in which the building boards formed only the ceiling, or only the walls of the room. As would be expected, the fire took longer to develop than in the previous series of tests, but the relative merits of different boards and treatments were similar. The results are summarized in Table 3, page 131.

Spread of Fire in Corridors

Requirements for linings to corridors are generally much more stringent than for other situations, as it is important that escape routes should present as low a fire hazard as possible. Since there is seldom any combustible material other than the floor in a corridor, there would be little risk of a fire originating there, and the main hazard would be in the spread of fire along a corridor from a burning room.

The spread of fire in a corridor would depend largely on the local conditions, for instance, the length of the corridor

(Continued on page 129)

After 10 minutes.

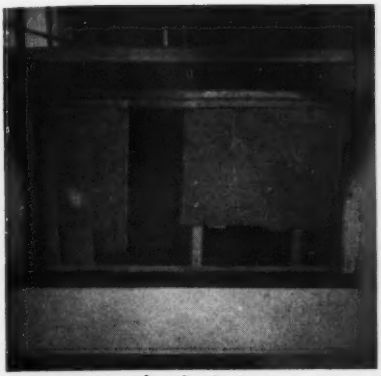
After 12 minutes.

After 16 minutes.

After 18 minutes.

After 19 minutes.

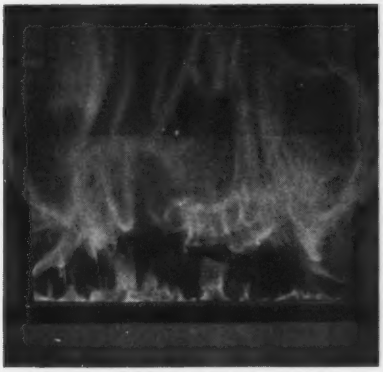
FIGURE NO. 4. DEVELOPMENT OF FIRE IN ONE-FIFTH SCALE MODEL ROOM WITH NONCOMBUSTIBLE WALLS AND CEILING.



After 2 minutes.

After 4½ minutes.

After 5 minutes.



After 5½ minutes.

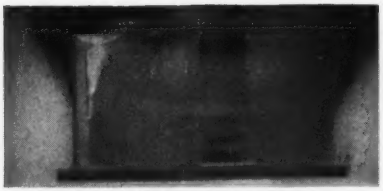
FIGURE NO. 5. DEVELOPMENT OF FIRE IN ONE-FIFTH SCALE MODEL ROOM LINED WITH UNTREATED FIBRE INSULATING BOARD.

and whether it opens into an unenclosed stairwell, which would tend to increase the air flow and draw flames and hot gases down the corridor. However, those boards which behave similarly to a non-combustible lining in a furnished room should not appreciably accelerate the spread of fire in a corridor under any conditions.

Other Considerations

No mention has been made of the unexposed surface of boards used as wall and ceiling linings. With a hollow construction, there is a danger that a fire starting in, or penetrating to, the cavity will spread rapidly on the inner surface. This danger would be particularly marked with those boards which can be ignited easily by a small source and from which a continuing fire will grow. Even if both sides of a combustible board are given protective coatings, an untreated surface may be exposed if the board is fractured. Although the area exposed will be rela-

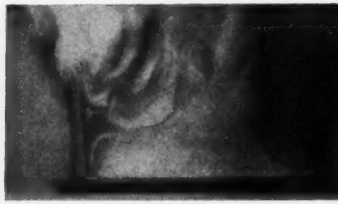
(Continued on page 131)



After 5 minutes.

After 6 minutes.

After 6¾ minutes.



After 7¼ minutes.

FIGURE NO. 6. DEVELOPMENT OF FIRE IN ONE-FIFTH SCALE MODEL ROO LINED WITH FIBRE INSULATING BOARD WITH FLAME-RETARDANT SURFAC TREATMENT.

Table No. 2

Particulars and Results of Boards Tested in Fully-Lined Rooms

Particulars of Wall and Ceiling Linings	Mean time for all roon become involved in f	
	Minutes	Secon
Noncombustible	17	10
Fibre insulating board with 3/16-in. skim plaster coat	17	45
Wood-fibred cement slab	16	45
Plasterboard	16	35
Hardboard impregnated with monammonium phosphate. (Retention of salt stated to be 17 to 18 percent by weight)	15	45
Hardboard with surface treatment of intumescent flame-retardant paint (30 grams per sq. ft.)	13	30
Fibre insulating board with surface treatment of intumescent flame-retardant paint (30 grams per sq. ft.)	10	35
Asbestos paper faced fibre insulating board	10	30
Fibre insulating board with surface treatment of intumescent flame-retardant paint (15 grams per sq. ft.)	9	25
Fibre insulating board impregnated with monammonium phosphate. (Retention of salt—9 percent by weight)	9	00
Fibre insulating board with surface treatment of silicate paint	7	45
Fibre insulating board with two coats of oil-bound water paint	6	00
Untreated hardboard	6	15
Compressed straw slabs	5	45
Untreated fibre insulating board	5	00

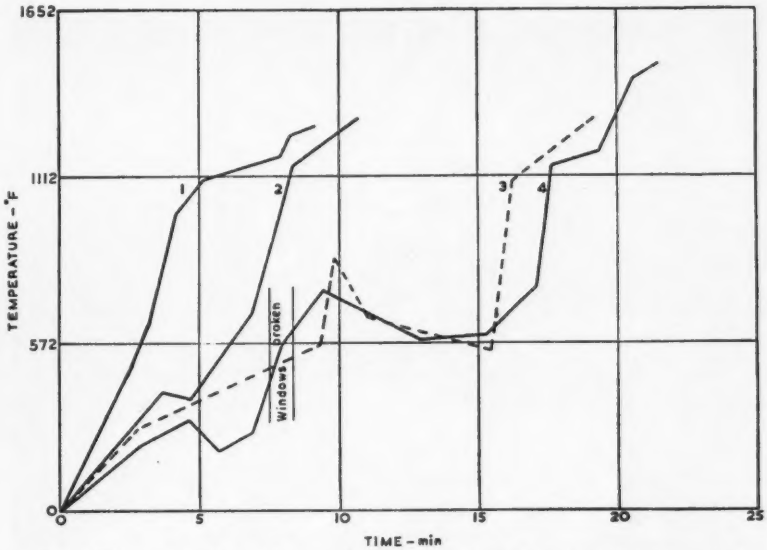


Figure No. 7. Selection of temperature records of model rooms. Line 1 represents tests with untreated fibre insulating board. Line 2 shows results of tests with fibre insulating board with surface treatment of an intumescent flame-retardant paint (15 grams per square foot). Line 3 shows results with a plasterboard and Line 4 with a noncombustible lining.

tively small, it may constitute a hazard if the untreated board can be easily ignited, particularly if the board is one which will continue smouldering with the production of smoke after flaming has ceased. It is therefore important to see that damaged surfaces are immediately repaired.

It is evident that the fire hazard of building boards depends, apart from the nature of the boards themselves, on the conditions under which they are used and, in particular, on the nature and amount of other combustible material with which they are associated.

Table No. 3

Particulars and Results of Boards Tested in Partially Lined Rooms

Treatment of fibre insulating board	Time for all room to become involved*			
	Boards used as walls; ceiling noncombustible		Boards used as ceiling; walls noncombustible	
	Minutes	Seconds	Minutes	Seconds
Surface treatment of intumescent flame-retardant paint (30 grams per sq. ft.)	13	45	12	00
Surface treatment of silicate paint	13	00	12	00
Surface treatment of oil-bound water paint	11	00	10	15
Untreated	8	20	9	00

*The times given in columns two and three of Table 3 are the average times of three tests, the maximum deviation from the mean being about 15 per cent.

Los Angeles County Fire Department

Oh for the life of a fireman! Captain "Sparky" McCrary illustrates the rigors attendant to all-out fire prevention promotion for dear old Los Angeles County! The model's name: Miss Anne Francis.

Sparky Lives In Los Angeles County

By Robert W. Schuette

Manager, NFPA Public Relations Department

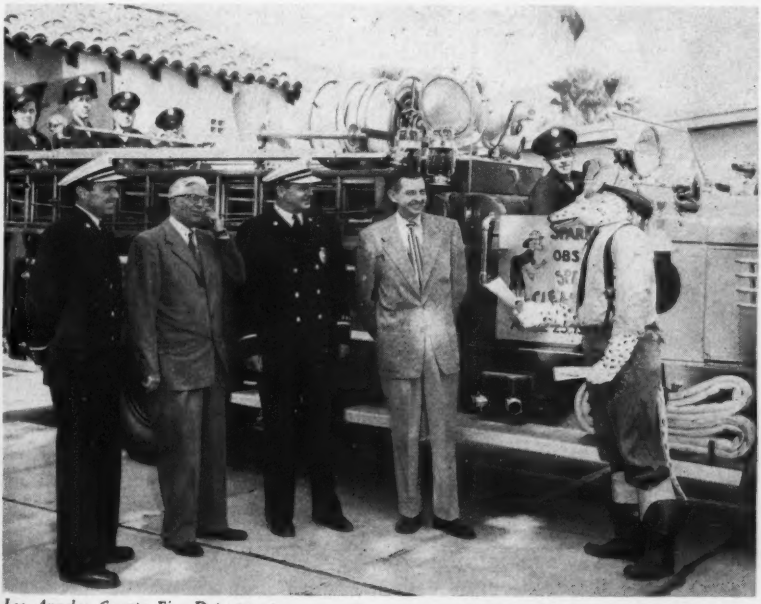
"*Sparky* should be live, whenever it can be arranged, a real live *Sparky* dressed in a fireman's hat . . . let him speak for you and work for you constantly."

This was the advice one of the country's top advertising experts had for the NFPA Annual Meeting last spring (see "Modern Promotion for Fire Prevention" published in the July 1954 QUARTERLY).

Across the country, the Los Angeles County Fire Department heard these words and could pat itself on the back. It seems that *Sparky*—"real and live"—has been a working member of Chief K. E. Klinger's Department in Los Angeles County for the past two years.

One of the earliest, if not the first *Sparky* to come to life, *Sparky* of Los Angeles County was born in 1952 during an intradepartmental fire prevention contest among the County's 86 fire stations. Brainchild of Captain A. F. McCrary (his wife made the mask and costume), *Sparky* has been the central theme of the County's fire prevention program since!

Ever since, too, Captain "Sparky" McCrary has been a very busy man. In addition to Fire Prevention Week and Spring Clean-Up, *Sparky* "in the flesh" is the feature of countless other fire prevention activities sponsored by the Department. He's on radio and TV the



Los Angeles County Fire Department

Sparky is "real and live" in Los Angeles County—a big strapping two-year-old. With the help of fellow members of Engine Company 38, Los Angeles County Fire Department, Sparky (Capt. A. F. McCrary) interviews (L to R) Chief Engineer Keith E. Klinger, County Supervisor Burton U. Chace, the late Chief Engineer Cecil R. Gehr, and Frank W. Troost of the Angeles Mesa Chamber of Commerce.

Sparky and pal, Smokey Bear, put on a show for 60,000 Scouts at the National Boy Scout Jamboree last year. This promotion received national press notice.

Sparky being interviewed by Ken Graue, KTLA announcer of the popular Los Angeles program, "City at Night."

Sparky is an idea, but it takes people to make that idea work. Capt. McCrary and Chief Klinger make Sparky click in Los Angeles County.

Los Angeles County Fire Department

It should happen to a dog . . . . . if he's Sparky. Not every fire department has a Hollywood in its backyard, but pretty girls are everywhere, and they are guaranteed attention-getters as in this Los Angeles County Fire Department publicity photo.

year-around and also stars at the Los Angeles County Fair and in half-time and pre-game activities when U. S. C. plays football in the Los Angeles Coliseum.

Sparky has been a hit from the start in school programs according to Chief Klinger. One of his biggest successes with kids took place last year when the National Boy Scout Jamboree was held in southern California. During the week-long jamboree, Captain McCrary as *Sparky* and Captain Robert Ballentine, dressed as *Smokey* Bear, appeared and performed together before nearly all the 60,000 scouts attending.

Sparky's public service partner, *Smokey* of forest fire prevention fame, has been integrated into the County's over-all program. An effective and necessary partnership, reports Chief Klinger, in that the Los Angeles County Fire Department also protects a great area of valuable watershed and forest lands.

On top of the Department's personalized efforts, over half a million *Sparky* leaflets have been produced and distributed to County residents in the past two years. Fire station personnel hand them out mostly during the Fire Prevention Week and Spring Clean-Up campaigns, but they're also used in connection with the Home Inspection Program. The Department doesn't miss a chance, either, to use *Sparky* posters, display cards and photos wherever possible.

Has the *Sparky* idea paid off in Los Angeles County? Says Chief Klinger: "It has helped a great deal to make our program what we consider an outstanding success."

Weather and Forest Fire Behavior*

By Owen P. Cramer, Meteorologist

Pacific Northwest Forest and Range Experiment Station
Forest Service, U. S. Department of Agriculture

Violent or erratic fire behavior during forest fires often develops as a complete surprise even to the more experienced fire fighters. Such behavior usually is not completely explained and is frequently dismissed with the remark that the fire suddenly "blew up." Unusual fire behavior is often closely related to certain weather conditions that can be recognized by visible characteristics. These weather conditions, some of their characteristics, and their relation to fire behavior are described in this article.

The descriptions and terminology used agree with definitions in the U. S. Weather Bureau *Weather Glossary*** of 1946, with two exceptions. These are *fire storm,* which has been used in published accounts of fires started from extensive incendiary bombings, and *fire whirlwind,* which is possibly used herein for the first time. Weather conditions described are divided into two major groups; the phenomena of stable air of which only *inversion* is discussed, and the phenomena of unstable air including ***turbulence, gustiness, convection, thundersqualls, whirlwinds*** and related characteristics.

Stable Air

Stable air is air in which vertical mo tions are suppressed primarily because o the vertical distribution of temperatur In stable air, underlying air is relativel cooler and heavier; overlying air is rel tively warmer and lighter. If the tempe ature decreases no more than 5° F pe 1,000 feet increase in elevation in dr air, the air is stable. In extremely stabl air, temperature may actually increas with height.

There are several indicators of stabl air. Surface wind is steady or frequentl calm. Smoke tends to lie in layer Clouds are the stratus or stratified typ showing no vertical motion (Figure 1) Visibility is often poor, particularly i the lower layers. Ground and valley fog form in stable layers near the ground Air in the lower layers is usually stabl during calm, clear nights, but become unstable in midday when heated by th warm ground.

When a forest fire occurs and the ai is stable, convective air circulation int the base of the fire and in the column of rising hot gases above a fire is weak Both the intensity of the fire and the amount of spotting† is reduced. In stable air, smoke will not rise as high

*Article reproduced by special permission from "Fire Control Notes," Volume 15, No. 2, April 1954, issued by the Forest Service, United States Department of Agriculture, where it appeared under the title "Recognizing Weather Conditions that Affect Forest Fire Behavior." It is reprinted to afford possible wider readership and because it is a unique contribution to a poorly understood subject.

**This Glossary is not presently available but should be available within six months.

†"Spotting," in forest fire terminology, means the spread of a fire by ignition from fire-brands beyond the existing range of ignition by direct radiation. Spot fires are identified as fires, started in this way, which are far enough away from the main fire to burn for a considerable time as independent fires.

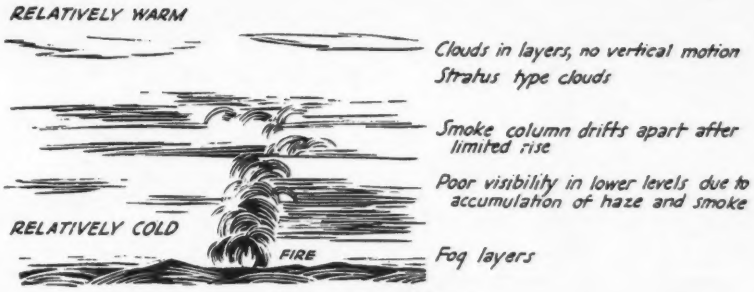

RELATIVELY WARM
Clouds in layers, no vertical motion
Stratus type clouds
Smoke column drifts apart after limited rise
Poor visibility in lower levels due to accumulation of haze and smoke
RELATIVELY COLD
FIRE
Fog layers

FIGURE 1.—Stable air.

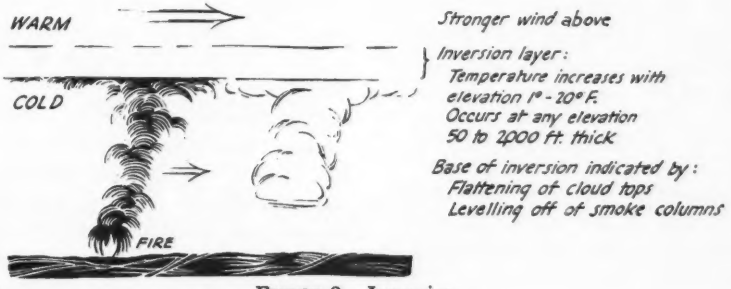


FIGURE 2.—Inversion.

as in unstable air and much drift smoke will remain in the lower layers.

Inversion Layers

A common phenomenon in stable air is an *inversion* layer. This is a horizontal layer of air through which temperature increases with increasing height. An inversion is the most stable air condition.

Inversion layers occur at any height and vary greatly in the thickness. As the ground cools at night, a surface layer of air becomes colder than the air above and produces a surface inversion.

Surface inversions are most pronounced in valley bottoms to which cold air flows from surrounding slopes. This type of inversion is readily dissipated by ground heating during the day.

Since an inversion tends to suppress any vertical motion, its base is frequently marked by: (1) the flat top of a cloud or fog layer, (2) the common height at which rising cumulus clouds cease to rise, and (3) the height at which a rising smoke column levels off (Figure 2). There is often greater wind, or a shift in wind direction, above the inversion as indicated in the Figure.

An inversion near the ground affects a fire in the same way as stable air but to a greater degree. In the lower layers it tends to weaken drafts into and above a fire, thereby reducing the fire's intensity and spotting potential. It has been suggested that flammable mixtures of gases liberated by a slow-burning fire might

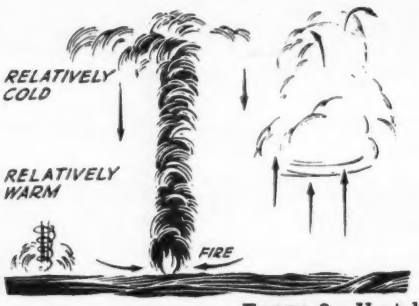


FIGURE 3.—Unstable air.

accumulate under a surface inversion, and that these might ignite and burn explosively but no evidence of this has been observed in actual fires.

Unstable Air

Unstable air is air that tends to turn over owing to relatively warm, light air in the lower layers and relatively cooler, heavy air in the upper layers. The decrease in temperature with increasing height is greater than in stable air, 5.4° F or more per 1,000 feet in dry air. Vertical motions are accelerated. Upward and downward currents develop. Indicators are erratic surface winds with gusts and lulls, and a variation in direction and turbulence above the surface layers. Since smoke, dust, and haze are widely dispersed by mixing of high and low layers, visibility is generally good. Clouds in unstable air are the cumulus type with pronounced vertical development and restricted horizontal area (Figure 3). A deep layer of moist, unstable air may be marked by cumulonimbus clouds or thunderstorms. Instability at the cloud level does not necessarily mean that this condition exists all the way to the ground. If it does exist, it may be indicated by dust whirls and erratic winds.

Unstable air affects fires in sever ways. Spread of fires may be accelerate by gusty wind. The column of smok over the fire will rise faster and to greate heights than in stable air, resulting in stronger indraft at the base of the fi and a hotter burning fire. Spot fires a more likely because of the more intens drafts in the fire and the greater vertic speed in the smoke column. Unstabl air is favorable for the formation of fi whirlwinds. These effects are discusse in more detail under the several insta bility phenomena described below.

Turbulence

Irregularity in air motion shown b bumpy air for the pilot and gusty win for the ground observer is called turbu lence. Any obstacle to the wind sets u mechanical turbulence on the leeward sid (Figure 4). Intermingled currents o rising warm and descending cool a cause thermal turbulence, which is cha acteristic of unstable air. Turbulenc may be accentuated by an uneven surfac heating that varies with color of soi amount of shade, and type of groun cover.

Gustiness

Gustiness is a characteristic of wind i unstable or turbulent air. Gustiness r

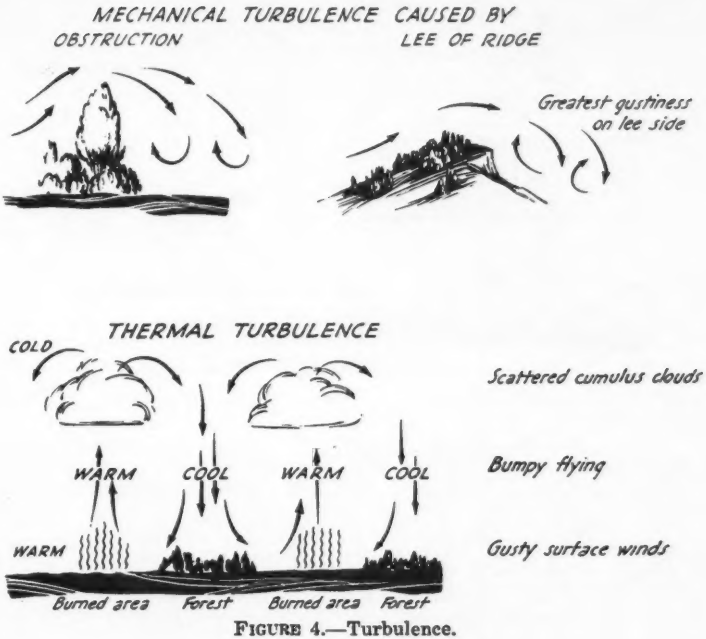


FIGURE 4.—Turbulence.

fers to surface winds that vary rapidly in vertical and horizontal speed and direction. Increasing instability and increasing turbulence caused by surface obstacles result in corresponding increases in gustiness. Since a fire greatly increases surface instability, the intensity of gusts is likely to be greater in the immediate vicinity of a fire. Gusts usually cause a fire to spread spasmodically in unpredictable directions. They also cause rapid fluctuation in fire intensity and rate of spread.

Convection

Motion in the air resulting from temperature differences in adjacent bodies of air is known as convection. Convective currents are characteristic of unstable air. They consist of rising warm air and descending cool air currents (Figure 5). Heating at the ground either by the sun or by fire may initiate the upward current. Surrounding air descends and flows toward the base of the column of rising air. The rising warm air above a continuing heat source is known as the convective column. Above a fire this is seen as the smoke column. Cumulus clouds are convective columns that have become visible because of moisture condensation. The greater the instability of the air or the greater the source of heat, the more intense becomes the convective circulation caused by a fire, including both indraft at the base and updraft in the smoke column. The more intense the convective circulation, the hotter and faster the fire will burn and the higher embers will be carried.

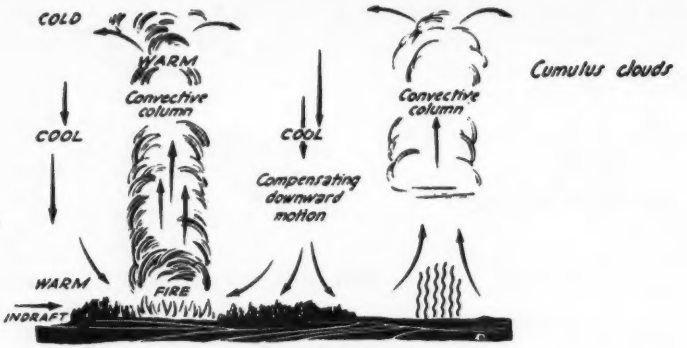


FIGURE 5.—Convection.

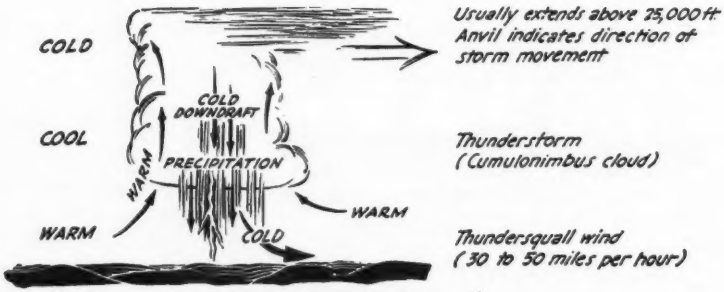


FIGURE 6.—Thundersquall.

Thundersqualls

The sudden wind that blows outward from beneath a thunderstorm is known as a thundersquall. Such a wind originates in the area of heaviest precipitation in a cumulonimbus cloud, a convective cloud type that occurs in unstable, moist air. Air, cooled by precipitation, descends from the cloud and fans out at the surface (Figure 6). The thundersquall usually occurs with a well developed thunderstorm and hits suddenly with speeds averaging 30 to 50 miles per hour for a period of several minutes. The thundersquall may occur beneath a thunderstorm from which no precipitation reaches th ground, and may extend outward a mil or more ahead of the storm edge.

These sudden, strong winds may swee a fire far beyond its confines before th rainy section of the thunderstorm arrives If the rain evaporates before reaching th ground, the fire may continue to bur unchecked.

Whirlwinds

A whirlwind is any revolving mass o air from the dust whirl to the hurricane The tornado, a whirlwind associated wit thunderstorms, is the most severe, thoug

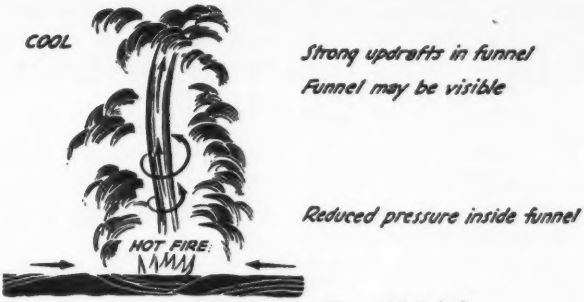


FIGURE 7.—Fire whirlwind.

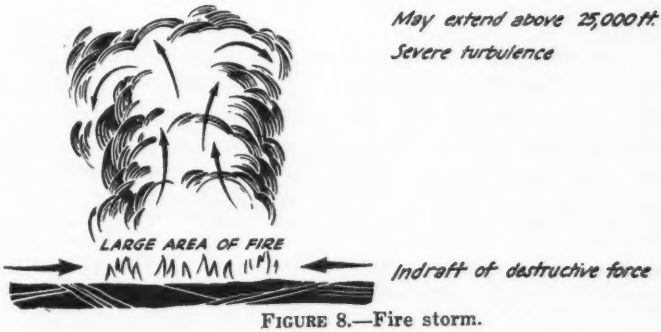


FIGURE 8.—Fire storm.

not the largest type. Whirlwinds usually occur in extremely unstable air. Fires frequently make the nearby atmosphere unstable and produce fire whirlwinds. Two types of whirlwind will be described, the dust whirl and the fire whirlwind.

A *dust whirl* is the smallest type of whirlwind and is frequently known as a *dust devil*. Dust whirls indicate unstable air. They occur on sunny days with light surface wind when the layers of air next to the ground become much hotter than the air immediately above. These whirls are usually 5 to 25 feet in diameter and may extend upward several hundred feet. Though usually not of destructive force, dust whirls can throw small debris several yards. The greatest speed is near the center where a strong upward current occurs. Dust whirls occasionally form in the vicinity of fires and move into the fire area throwing sparks and embers in all directions and temporarily intensifying the fire as they pass.

A *fire whirlwind* is any whirlwind that is caused by a fire. The fire whirl-

wind may vary in intensity from a small dust whirl to a whirlwind that easily snaps off large trees. The diameter of its circulation may vary from 3 to 50 yards or more. Fire whirlwinds encompassing whole fires 1,000 yards or more across have been reported. Besides the rotating horizontal winds, there is a strong vertical current at the center which may raise burning debris to great heights. Even a small fire whirlwind may produce considerable spotting and local intensification of the fire. A central spout or tube may sometimes be present (Figure 7).

Because of the wind and the resulting accelerated combustion, fire whirlwinds are sometimes accompanied by a roaring noise similar to that produced by a rapidly burning fire. Duration and behavior are variable. Fire whirls may occur and recur where the combination of fire-produced instability, topography, and wind are favorable. It is sometimes possible to dissipate a small, recurring fire whirlwind by cooling the part of the fire over which it forms.

Fire Storm

Violent convection caused by a large, continuous area of intense fire is properly called a fire storm. This phenomenon was frequently observed after extensive fire-bomb raids in Europe and Japan. The convective system usually encompasses the entire fire (Figure 8). The surface draft into the base of the fire may be of destructive violence several hundred yards outside the fire. The fire storm, like other convective phenomena, increases in intensity with greater atmospheric instability. Burning material may be lifted several miles high. A fire storm is not likely in the usual wildfire where only the periphery is actively burning.

EDITOR'S NOTE: In the April 1934 QUARTERLY (page 323), H. J. Gisborne in an article "Measuring Forest Fire Danger" discussed the development of a "Forest Fire Danger Meter" which aids in appraising the influence of wind velocities and the moisture content of forest fuels. "Forest Fire Weather Forecasting" by Roy Headley, appearing in the October 1939 QUARTERLY, analyzed the effects of weather on forest fire behavior and emphasized the need for accurate and reliable weather forecasting as a tool for effective forest fire prevention and as an aid in fire fighting operations. David P. Godwin discussed the use of "Helicopters for Forest Fire Control" in the July 1946 QUARTERLY and notes the role aerial observation may play in detecting the influence of weather on forest fire behavior. Most recently, A. A. Brown, Chief, Division of Fire Research, U. S. Forest Service, wrote an article for the July 1950 QUARTERLY in which he also noted the importance of having forest fire fighters trained in observations of meteorological conditions. The text above should assist all concerned in recognizing the important weather conditions which have a marked influence on how forest fires may be intelligently suppressed.

Halogenated Extinguishing Agents

Based on Material Prepared by
Harvey L. Hansberry, Department of Commerce, Civil Aeronautics Administration
Howard A. Klein, Department of the Air Force, Wright Air Development Force
James E. Malcolm, Department of the Army, Corps of Engineers
Arthur V. Stamm, Department of the Navy, Bureau of Aeronautics
Edmond G. Young, E. I. duPont de Nemours & Company

EDITOR'S NOTE: In the October 1951 Quarterly of the NFPA, an article under this title was published to advise interested members of the Association about the research work which had been conducted up to that time by the Jackson Laboratory of E. I. duPont de Nemours & Company (designated Part I) and by the Engineer Development and Research Laboratories of the United States Army (designated Part II). Reprints of this article (identified as NFPA No. Q45-10) are available from the NFPA for 50 cents each.

This present article is divided into five parts (designated Parts III through VII) and reports on the progress, as seen by the authors, which has been made during the three years since Parts I and II were published. The opinions expressed in the material published herein are those of the authors.

It should be emphasized that research is continuing on these and other extinguishing agents and that practical fire extinguishment applications have not been completed. As further data becomes available the NFPA will attempt to keep its members advised.

Much of the information published herein is based on material presented or prepared for presentation at the 58th. NFPA Annual Meeting held in Washington, D. C., May 17-21, 1954.

Part III*

Research at the Technical Development and Evaluation Center Civil Aeronautics Administration[1]

By Harvey L. Hansberry, Chief, Power Plant Branch

The work of the Civil Aeronautics Administration, Technical Development and Evaluation Center, with halogenated hydrocarbon extinguishing agents is limited to their use for protection against aircraft powerplant fires in flight. Our work is not yet complete so this is in the nature of a progress report.

For complete evaluation of any new agent we prefer to work with it over a reasonable period of time, in all types of aircraft powerplant configurations, under various air flow and fire conditions. In earlier times, literally hundreds of tests were required under a wide variety of conditions to properly evaluate carbon dioxide (CO_2) and methyl bromide (CH_3Br) for use in aircraft engine extinguishing systems. We want to develop the same basis for evaluating dibromodifluoromethane (CBr_2F_2) and bromotrifluoromethane ($CBrF_3$), designated, for convenience in reference, as Halon 1202 and

*For Parts I and II, see October 1951 NFPA Quarterly or NFPA Pamphlet No. Q45-10 as explained in Editor's Note above.

[1]For background data, see NFPA Quarterly, July 1948, pages 38 to 45 and NFPA Aviation Bulletins No. 46 (50 cents) and No. 94 ($1.00) available from the Association.

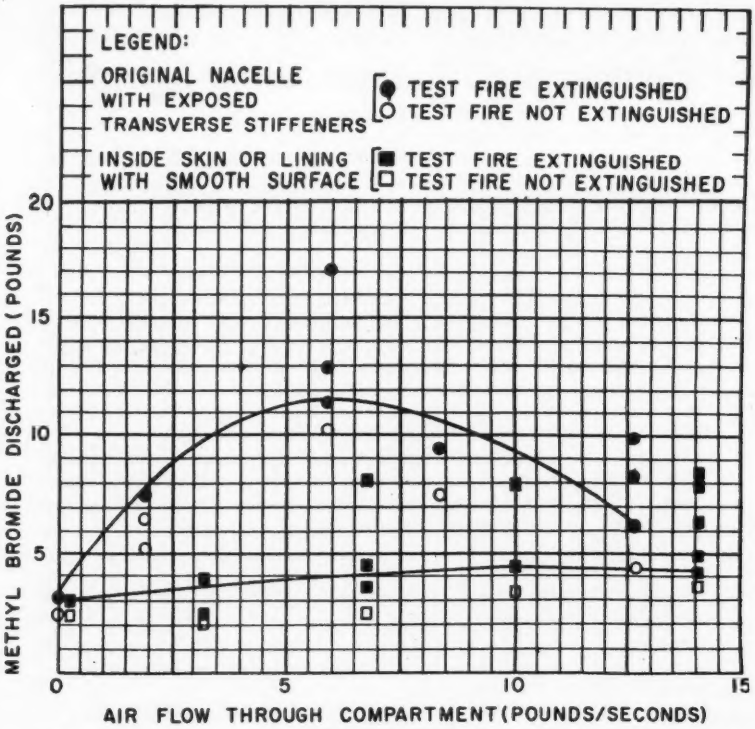


Figure 1. CAA fire extinguishing test results with methyl bromide (Halon 1001) under various conditions of air flow in a jet aircraft powerplant. This test used the CAA experimental high rate discharge system.

Halon 1301 respectively.[2] It is these two halogenated hydrocarbons which have received our greatest attention during the past three years.

From the standpoint of comparing these two new agents, it is unfortunate that since we started our test work earlier with Halon 1202 than with Halon 1301, we have never tested the two against each other or even against any one test standard. We have compared Halon 1202 with methyl bromide (Halon 1001) and Halon 1301 with carbon dioxide.

During fire extinguishment tests in the powerplant of a new U. S. Air Force jet bomber (designated the XB-45), a significant number of tests were conducted which compared the fire fighting abilities of methyl bromide and Halon 1202 using various air flows through the powerplant of from zero to 15 pounds per second to simulate ground and flight fire conditions.[3] This work is completely covered in CAA Technical Development Report

[2]Halon numbers are designed for convenient and quick reference to the numerous chemical compounds known as "halogenated hydrocarbons." The first digit of the number represents the number of carbon atoms in the compound molecule; the second digit, the number of fluorine atoms; the third digit, the number of chlorine atoms; the fourth digit, the number of bromine atoms; the fifth digit, the number of iodine atoms. In this system terminal zero digits are not expressed.

[3]Available from the CAA.

No. 205. As a result of those tests, it was concluded that the extinguishing abilities of methyl bromide and Halon 1202 were essentially identical, which means that Halon 1202 is a very good extinguishing agent. Both methyl bromide and Halon 1202 performed more effectively on a pound for pound basis than did carbon dioxide or bromochloromethane* (Halon 1011), which were used for comparative purposes. (See Figures 1, 2, 3 and 4, which graphically present the results achieved using a CAA experimental high rate discharge system installed in the test engine.)

*In an effort to standardize chemical terminologies and to be chemically accurate, CH_2BrCl (Halon 1011) will be referred to herein as "bromochloromethane" rather than "chlorobromomethane" (often referred to as "CB" or "CBM" in the trade).

At present, we are conducting tests in a simulated Lockheed Constellation powerplant. The interior arrangements of the test sections are geometrically identical with the installation in the actual nacelle of a Constellation. The objective of the work is to determine whether an increase in fire fighting ability would result by replacing the carbon dioxide in the existing powerplant fire extinguishment system with Halon 1301. No changes have been made in the extinguishing system which incorporates a feed line one inch in diameter and 76 feet long with four discharge

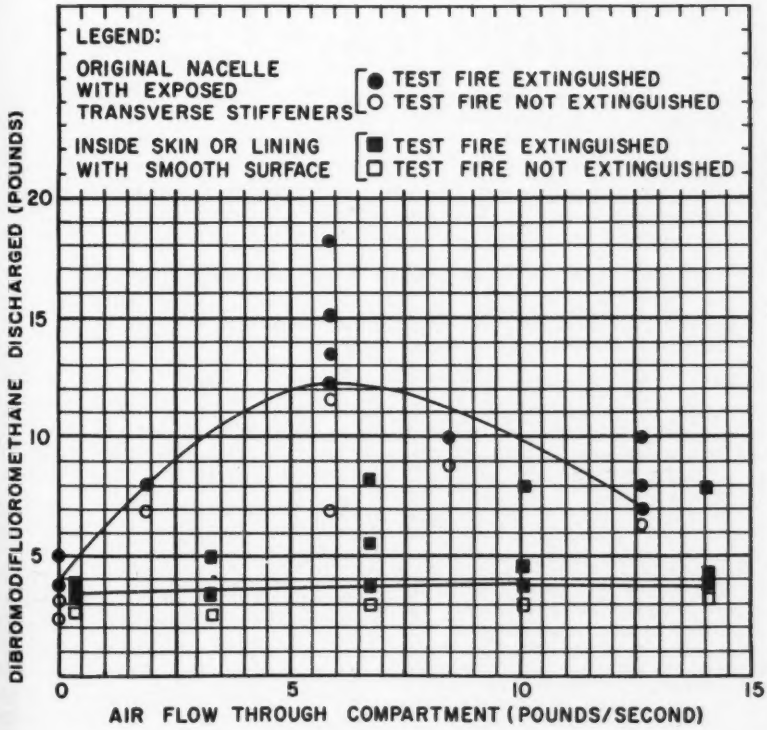


Figure 2. CAA fire extinguishing test results with dibromodifluoromethane (Halon 1202) under various conditions of air flow in a jet aircraft powerplant. This test used the CAA experimental high rate discharge system.

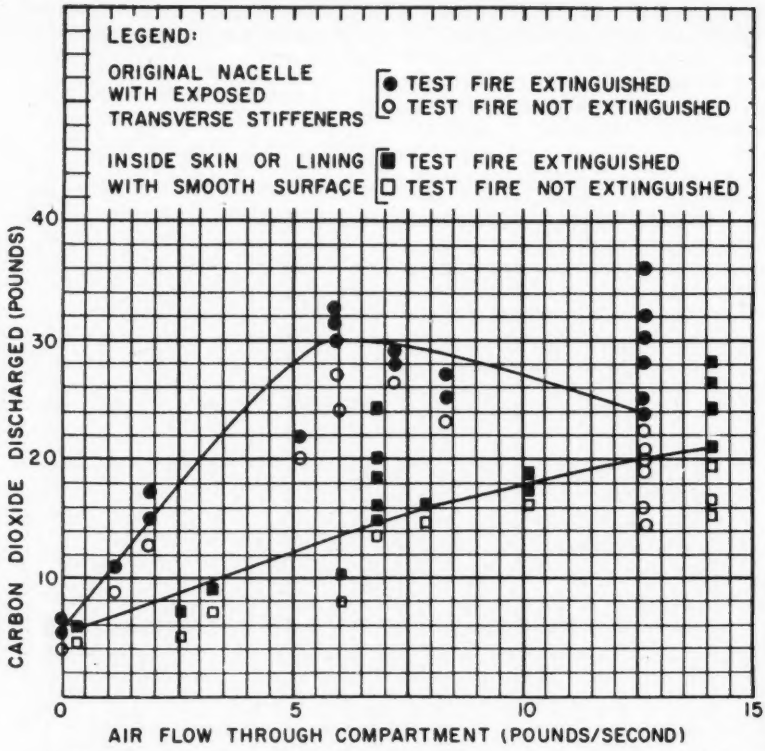


Figure 3. CAA fire extinguishing test results with carbon dioxide under various conditions of air flow in a jet aircraft powerplant. This test used the CAA experimental high rate discharge system.

nozzles in each of two separate "zones" in the powerplant.[4] It is known that little, if any, air flows through the aft auxiliary power compartment zone under flight conditions, but the air flow through the engine accessory section is unknown. Accordingly, the air flow in the accessory section was varied from one to four pounds per second. Minimum quantities of the two agents required to extinguish the severest fires obtainable under the various air flows are given in Table No. 1.

The quantities noted extinguished simultaneous fires and the results indicate a clear superiority of Halon 1301 over carbon dioxide. That superiority appears great enough to put Halon 1301 in the same class as methyl bromide and Halon 1202.

Direct comparisons between the new agents are yet to be made, but will be accomplished on existing and future test installations at our Laboratory. One of the major efforts in future work will be to de-

(Continued on page 148)

[4]Aircraft powerplants (engines) are, for convenience, divided in three fire "zones." Zone 1 is the "power section" forward of a diaphragm which separates it from Zone 2 which comprises the "accessory section." Behind Zone 2 is Zone 3 which is likewise separated by a diaphragm. The diaphragms act as "fire walls" to separate each zone and the extinguishing systems are designed to handle each zone's requirements which vary due to air flow differences under flight conditions. (For further details, see Chapter 68, NFPA Handbook of Fire Protection, Eleventh Edition.)

Table No. 1

Research by CAA Technical Development and Evaluation Center

Comparison of Effectiveness of Carbon Dioxide and Bromotrifluoromethane (Halon 1301) in Extinguishing Severe Aircraft Engine Fires

Pounds of Agents Tested	Quantity of Air Passing Through Engine Accessory Section (Pounds/Second)			
	1	2	3	4
Pounds Carbon Dioxide Required	7.1	13.1	21.25	21.8
Pounds Halon 1301 Required	3.5	6.0	6.0	6.0

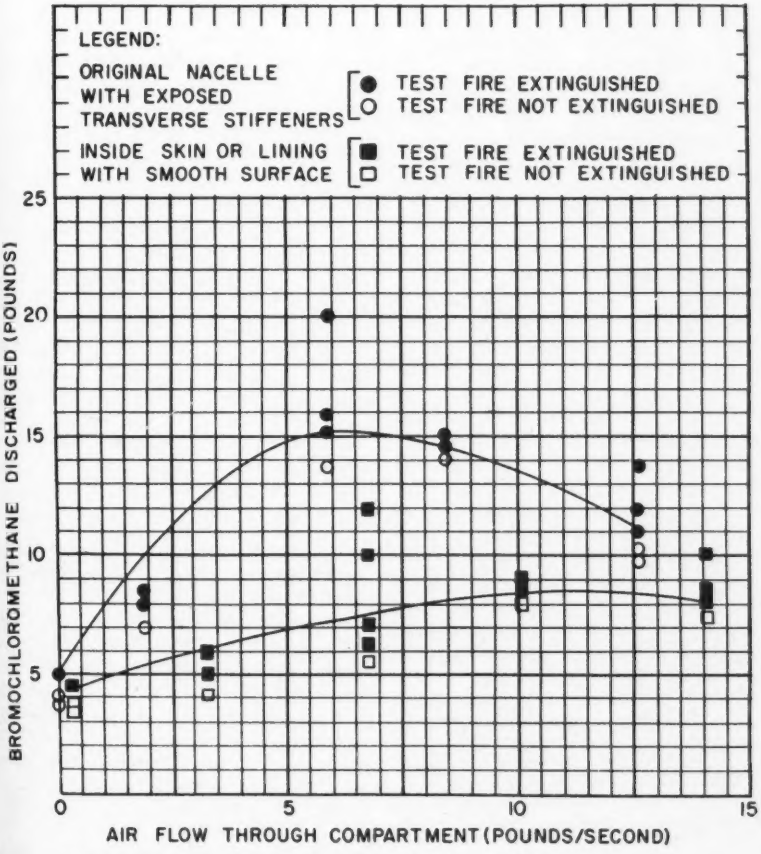


Figure 4. CAA fire extinguishing test results with bromochloromethane (Halon 1011) under various conditions of air flow in a jet aircraft powerplant. This test used the CAA experimental high rate discharge system.

termine the optimum system for use with each new agent as the effectiveness of any agent evaluated in the past depended, to some extent, on the system and method of discharge which was used with it. Based on the tests briefly described above and on isolated tests under various fire conditio we believe both dibromodifluorometha (Halon 1202) and bromotrifluorome ane (Halon 1301) will prove to be ve satisfactory extinguishing agents for co bating aircraft powerplant fires in fligh

Part IV

Research By Wright Air Development Center[5] Department of the Air Force

By Howard A. Klein, Aircraft Fire Protection Section

At the May 1951 NFPA Annual Meeting, the United States Air Force fire extinguishing agent development program was presented in summary form.[6] It is the purpose of this paper to acquaint this Association with the developments which have taken place between 1951 and the present date.

Bromochloromethane Now Standard

Virtually all USAF aircraft powerplant fire extinguishing systems have been transformed from carbon dioxide and methyl bromide (Halon 1001) to bromochloromethane (Halon 1011). With few exceptions, only the old World War II aircraft such as the C-46, C-54, B-17 and B-26 contain carbon dioxide powerplant fire extinguishing systems.

The USAF has utilized bromochloromethane (Halon 1011) with some notable success. You may recall that on May 3, 1953, a C-119 (known as the "Flying Boxcar") with 40 passengers on board had an engine fire in flight over Victorville, California. The passengers bailed out to decrease the weight of the aircra and thereby improve the flight charact istics of the aircraft operating on only o of its two engines. The fire in the bur ing engine was extinguished with Hal 1011 and the expensive aircraft was sav from destruction.

In another incident a crew memb crawled into a wing of a C-124 ("Glob master") aircraft and extinguished an e gine fire with a one-quart portable br mochloromethane extinguisher (Ty A-20[7]) by opening the fire wall door a squirting Halon 1011 on the burni generator. The fire was extinguished a the hot generator cooled down by t Halon 1011 liquid to below the ignitio temperature of the gasoline which w leaking onto the generator.

In another case, again involving C-119, an engine fire was controlled flight but not completely extinguishe The aircraft was landed and the cre chief extinguished the residual fire wit one Type A-20 bromochloromethane e tinguisher. The damage was relative slight and the aircraft saved.

Of course, just as in the case of groun fire fighting where buildings are som times lost, so are there cases where w have failed to extinguish an engine fire i

[5]For background data, see NFPA Quarterly, April 1950, page 235. See also NFPA Aviation Bulletin No. 44 (available from the Association for $1.00 per copy).

[6]See NFPA Aviation Bulletin No. 70, "USAF Aircraft Fire Extinguishing Agent Development Program" by Raymond R. Stasiak, USAF. A. B. No. 70 is available from the NFPA Executive Office for 25 cents each. See also Proceedings, 55th NFPA Annual Meeting, page 171.

[7]See NFPA Aviation Bulletin No. 55, "USA Military Specification for Aircraft Extinguis er; Type A-20. A. B. No. 55 is available fro the NFPA Executive Office for 25 cents each

flight. These failures may have been due to a variety of reasons, including poor fire emergency procedure or late fire detection, with resultant severe fires incapable of being coped with by the limited amount of airborne agent available.

To increase our ability to fight fires in flight with smaller amounts of agent and to increase the probability of extinguishment of a given fire with the same amount of agent, it is necessary that improvements be made in agent efficiency.

Dibromodifluoromethane Developments

It was mentioned in 1951 that effort was being expended on a new agent, dibromodifluoromethane (Halon 1202). In the same volume cylinder which we formerly could charge with 16 pounds of Halon 1011, we can now get 19 pounds of Halon 1202. In addition, Halon 1202 is more effective. The advantages are obvious. We get more fire protection per pound of equipment and per pound of agent, without requiring precious extra aircraft space. In addition, Halon 1202 can be utilized in the same equipment as Halon 1011 with fewer corrosion problems.

Since 1951, Halon 1202 has been evaluated at a number of other testing facilities including those of the Civil Aeronautics Administration (see Part III of this article) and Aerojet — General Corp. The Aerojet effort was performed under a USAF Contract and is described in Air Force Technical Report 5876 "Rocket Fire Protection."[8] This latter work proved conclusively that Halon 1202 can extinguish a rocket fire combination of fuel and oxidizer.

These data and other results reported herein, plus approval for the use of Halon 1202 from a toxicological viewpoint (by the Air Surgeon, Air Materiel Command), have all pointed towards the acceptability of the agent for future USAF use and limited applications of Halon 1202 have already been made.

On October 20, 1952, during a ground check of the Bell X-1A aircraft, a fire occurred which was detected by the thermal switch fire detector. This automatically initiated the fire extinguishing system containing Halon 1202 and the fire was extinguished with such rapidity that it wasn't known that a fire existed until the engine was inspected shortly thereafter.

There is a possibility that one type of USAF bombardment aircraft and one USAF cargo aircraft may utilize Halon 1202 in the near future. In addition, a number of other special applications for the agent have been made. However, to date, no over-all change from Halon 1011 to Halon 1202 has been made. Any future change to Halon 1202 would be accomplished on new aircraft and on depletion of the existing Halon 1011 supply, both in stock and aboard aircraft. Since Halon 1202 can be utilized in existing equipment, this change can be readily accomplished in both low pressure, fixed aircraft systems and in portable hand fire extinguishers.

Other Research — Magnesium

The USAF is also conducting development on other special fire extinguishing agents. Magnesium fires offer a special challenge to fire fighters. Carbon dioxide, water, nitrogen and the halogenated agents combine chemically with burning magnesium and thus these materials are unsatisfactory as fire extinguishing agents. The judicious application of water to magnesium may result in cooling the metal below its ignition point and thus achieve extinguishment, but, at best, this is a very dangerous operation which could lead to the spread of the fire.

The presence of magnesium and gasoline in aircraft presents special problems. These are not small machine shop type magnesium fires. Sand, salt or various other powders have been found unsatisfactory in this usage. Therefore, the Southwest Research Institute at San An-

[8]See also NFPA Aviation Bulletin No. 91, "USAF Studies on Fire Extinguishing Agents for Rocket Fuels." A. B. No. 91 is available from the NFPA Executive Office for $1.00 each and briefs AF Technical Report No. 5872 prepared under contract with the USAF by Purdue University.

tonio, Texas and the Francis Earle Laboratories at Peekskill, New York have investigated the magnesium fire problem for the USAF. It is anticipated that their reports will be available in the near future. Glycols, phosphates and borates appear to be the most promising magnesium fire extinguish'ng agents.

Other Research — Foam

With regard to mechanical foam, the USAF relies largely upon the Navy for development effort. There is one exception, however, wherein the USAF has performed some work on alcohol foam which has been reported in AF Technical Report No. 6130, "All-Purpose Fire Extinguishing Foams." It is planned to evaluate all-purpose foams from different sources as to suitability for hydrocarbon and alcohol fires.

USAF Fire Record

Significantly, the fire accident rate has been decreasing. During the last quarter of 1953 the number of fire accidents has been the smallest since careful compilation of fire accident records was initiated some years ago. USAF aircraft have never been so well designed with regard to fire prevention, detection and extinguishment and, to a large extent, the improvements in fire extinguishing agents have been responsible for this increased success in fire protection.

Part V

Research by Engineer Research and Development Laboratories Corps of Engineers, U. S. Army[9]

By James E. Malcolm, Chief Agents and Techniques Section
Fire Fighting Branch

The basic laboratory and small scale evaluations of the research conducted on new halogenated extinguishing agents by the Department of the Army were discussed in Part II of the article on this subject in the October 1951 QUARTERLY (See Editor's Note, page 143). Since the spring of 1951, the avenues of investigation have included the following:

a. Further toxicological studies on the agents at the Army Chemical Center Medical Laboratories.

b. Design and development of a one quart size extinguisher unit for use with bromotrifluoromethane (Halon 1301).

c. Investigation of the use of 15 and 50 pound size extinguishers for use with bromotrifluoromethane (Halon 1301).

d. Design of 15 and 50 pound bromotrifluoromethane (Halon 1301) extinguisher components, i.e., nozzle, valve, etc., and a field charging unit.

Toxicological Studies

Several investigations have been conducted at the Medical Laboratories in the field of vaporizing liquid fire extinguishing agents, and two concern the comparative evaluation of agents of interest at this time.

Medical Laboratories Research Report No. 107 presented results of studies on the inhalation toxicities of the decomposition products of carbon tetrachloride, bromochloromethane (Halone 1011), dibromodifluoromethane (Halon 1202), and bromotrifluoromethane (Halon 1301) when used on gasoline fires. In these studies vapor exposures were made to 40 rats and 20 mice for 15 minutes in each evaluation. The tests were conducted in a 20 cubic meter (680 cubic feet) exposure chamber. The room was fire re-

(Continued on page 153)

[9]For background data, see Part II in the October 1951 NFPA Quarterly or NFPA Pamphlet Q45-10 as explained in the Editor's Note, page 143).

Table No. 2

Results of Tests by Chemical Corps Medical Laboratories

Concentrations of Fire Extinguishing Compounds and Their Decomposition Products Showing Mortality to Mice and Rats

After Discharge of the Contents of a Three Pound Fire Extinguisher

Agent	Concentration in mg x $10^3/m^3$			Chamber Temperature		Relative Humidity	Mortality Within 14 Days	
	Agent	Carbon Monoxide*	Carbonyl Halides as $COCl_2$**	Before Fire	After Fire		Mice	Rats
	mg x $10^3/m^3$			°F	°F	Per cent	Per cent	Per cent
			Fire Only					
Fire Only	0	0.023	Negative	72	125	69	0	0
			Unaltered Vapor — No Fire					
CCl_4	106	0	0	68		96	5	0
Halon 1011	76	0	0	85		47	0	5
Halon 1202	67	0	0	68		80	5	0
Halon 1301	65	0	0	71		86	0	0
			Rapid Extinguishment of Fire					
CCl_4	41	0.009	0.0004	76	86	78	5	10
Halon 1011	20	0.011	0.0004	75	95	62	0	3
Halon 1202	15	0.011	Negative	69	82	86	80	15
Halon 1301	16	0.011	Negative	68	82	76	0	6
			Slow Extinguishment of Fire					
CCl_4	18	1.1	0.04	67	122	53	10	33
CCl_4	30	1.1	0.05	64	91	84	10	33
Halon 1011	82	1.1	0.02	75	120	80	20	8
Halon 1011	47	1.1	0.03	84	108	62	32	29
Halon 1202	43	1.1	0.02	66	113	71	37	0
Halon 1202	20	1.6	0.06	81	122	61	100	9
Halon 1301	11	1.1	Trace	64	122	65	0	0
Halon 1301	14	1.1	Trace	81	124	50	5	3

* To convert to parts per million, multiply by 0.873

** To convert to parts per million, multiply by 0.247

Table No. 3

Engineer Research and Development Laboratories

Comparison Two Foot Diameter Tub Fire Tests(*) of Three Conventional Agents and Bromotrifluoromethane (Halon 1301)

Agent	Type Application	Nominal Extinguisher Capacity	Approx. Rate of Discharge	No. of Tests Reported	Average Weight to Extinguish 2 Ft. Diameter Tub Fire	Average Extinguishment Time
Carbon tetrachloride	liquid stream, pressurized to 180 psig	about 3 lbs	0.1 lb/sec**	1 2	2.5 lb no ext	18 sec no ext
Carbon tetrachloride	liquid stream, from double acting pump gun	about 3 lbs	0.1 lb/sec	9	no ext	no ext
Bromochloromethane (Halon 1011)	liquid stream, pressurized to 180-185 psig	about 3½ lbs	0.2 lb/sec	3	1.25 lb	6 sec
Carbon dioxide	vapor stream, 800 psig cylinder pressure	4 lbs (similar results were obtained with 5 lbs unit)	0.2 lb/sec	1 8	2.25 lb no ext	13 sec no ext
Bromotrifluoromethane (Halon 1301)	vapor stream, 400 psig cylinder pressure with N_2 pressurization	2¾ lbs	0.2 lb/sec	9†	0.6 lb	2.5 sec

* Essentially per U.L. Lab. procedure, except conducted outdoors.
** Discharge rate decreased during discharge cycle giving lower over-all rate.
† Seven extinguisher charges used. With other tests, each test was conducted with fresh charge.

sistive in construction. On one side, the animal cages were suspended 5 feet from the floor. The cages were covered with a fire retardant treated cloth curtain which could be raised and lowered by means of a rope and pulley from outside the chamber. The curtain provided heat protection for the animals in the fire tests.

In the center of the room, a galvanized iron pan 1 inch high and 12 inches square was used to contain one-half pint of gasoline (80 octane). There was no tetraethyl lead in the gasoline. It was ignited by two squibs which were connected electrically and discharged from outside the chamber. In a corner opposite from the animal cages a 10 inch fan was placed for circulating chamber air after the fire was extinguished and after the animal exposures were initiated.

Approximately 5 feet from the floor of the chamber next to the animal cages, the nozzle of the fire extinguisher was inserted into the chamber and directed downward to the base of the pan containing the gasoline. The fire extinguisher was operated from outside the chamber. The agent under about 400 pounds of nitrogen pressure was released into the chamber by a trigger mechanism such as is on a standard carbon dioxide type extinguisher.

The following methods were used in the test program:

a. For the fire only tests, gasoline was placed in the pan and ignited. The fire burned for approximately 2 minutes. Animals were exposed for 15 minutes and then removed from the chamber.

b. For the unaltered vapor tests, approximately 3 pounds of fire extinguishing agent was discharged immediately (within 15 seconds) from the fire extinguisher into the chamber. No gasoline was placed in the chamber. The animals were exposed for 15 minutes and then removed from the chamber.

c. For the rapid fire extinguishment tests, one half-pint of the unleaded gasoline was placed in the 12 inch square by one inch high pan and ignited. The fire was then put out in about 15 seconds by one of the fire extinguisher charges. (The amounts of the various agents tested to secure extinguishment were approximately 2.6 pounds of carbon tetrachloride, 1.3 pounds of Halon 1011, 0.9 pounds of Halon 1202, and 0.3 pounds of Halon 1301.) After extinguishing the fire, the curtain was raised from the animal cages to expose the animals. To prevent raw gasoline from evaporating, the pan was covered by a sheet of thin metal which was initially supported by a rod. After the fire was extinguished, a cord attached to the rod was pulled, allowing the metal sheet to fall on the pan to cover unburned gasoline.

d. For the slow fire extinguishment tests, the contents of one fire extinguisher were discharged into the chamber. Then the gasoline was ignited and allowed to burn out. The burning time of the fires varied from 30-60 seconds. The remainder of the procedure was the same as in the rapid extinguishment tests.

To supplement the animal observations, air samples were taken during the exposure periods and analyzed for extinguishing agent, carbonyl halides, carbon monoxide, oxygen, carbon dioxide, free halogens, and halogen acids.

The results of these studies are summarized in Table No. 2. It is of particular interest to note that Halon 1301 produced only trace amounts of carbonyl (phosgene like) compounds, whereas the other agents tested in the slow extinction method showed from 20 to 60 micrograms of carbonyl halide per cubic meter (based on the weight of phosgene).

Medical Laboratories Research Report 180 covers chronic exposure studies with bromotrifluoromethane (Halon 1301) and dibromodifluoromethane (Halon 1202). In this study rats and dogs were used. With bromotrifluoromethane (Halon 1301) at 2% concentration in air (by volume), no effect, other than some congestion observed on autopsy, was noted after almost 500 cumulative hours of exposure. With dibromodifluoromethane (Halon 1202) at 0.2% concentration, dogs were paralyzed and became unconscious after 120 cumulative hours of ex-

* Essentially per U.L. Lab. procedure, except conducted outdoors.
** Discharge rate decreased during discharge cycle giving lower over-all rate.
† Seven extinguisher charges used. With other tests, each test was conducted with fresh charge.

Table No. 4

Engineer Research and Development Laboratories

Comparison Tests on Five Gallon Gasoline Spill Fires* Using Bromotrifluoromethane (Halon 1301) and Several Comparison Extinguishing Agents

Halon 1301 Discharged at Approximately One-Half Pound Per Second

Extinguishing Agent	Type Extinguisher	Number of Fires	Percent of Fires Extinguished	Weight of Agent Used Per Fire, Extinguished (Averaged) lbs: oz	Time for Extinguishment (Averaged) Seconds
Bromotrifluoromethane (Halon 1301)	15 lb CF_3Br	15	100	4:13	8
Bromotrifluoromethane (Halon 1301)	15 lb CO_2	20	100	7:6	12.3
50% Methyl bromide 50% Bromotrifluoromethane	15 lb CF_3Br	10	100	8:9	11.8
75% Methyl bromide 25% Bromotrifluoromethane	15 lb CF_3Br	10	100	9:8	10.8
50% Ethyl bromide 50% Bromotrifluoromethane	15 lb CF_3Br	10	90	9:3	13.9
75% Ethyl bromide 25% Bromotrifluoromethane	15 lb CF_3Br	10	80	9:8	13.6
Bromochloromethane (Halon 1011)	15 lb CF_3Br	5	100	14:2	16.0
Carbon dioxide	15 lb CO_2	5	40	10:6	17.0

* In conducting these tests 5 gallons of gasoline were spilled on a concrete slab in a path approximately 3 ft. wide and 25 ft. long. A twenty second preburn was allowed before extinguishment was attempted.

posure; rats showed pronounced reaction and deaths resulted after 120 hours of exposure.

Extinguisher Developments

From fire tests and studies of the characteristics of bromotrifluoromethane (Halon 1301), a charge of 2.75 pounds for an extinguisher volume of 69 to 70 cubic inches was selected, pressurized with nitrogen gas to give a total internal pressure of 400 pounds per square inch at 70° F. It was also found that a slight modification could be made to the charge so that the total pressure at 130° F could be kept under 625 pounds per square inch and thus permit use of a welded extinguisher container complying with the Interstate Commerce Commission requirements for compressed and liquefied gases. (Nitrogen pressurization is used to facilitate extinguisher discharge characteristics at the extreme low temperatures.)

The 2¾ pound extinguisher is a nominal one quart unit. The relative performance of the one quart (or 2¾ pound) bromotrifluoromethane (Halon 1301) type extinguisher, compared with other current extinguishers used by the Army and two pressurized units used industrially, is indicated in Table No. 3.

In the comparisons presented, the following current types of extinguishers were used: (1) a pressurized carbon tetrachloride extinguisher, one quart size; (2) a standard double acting carbon tetrachloride pump gun, one quart size; (3) a pressurized bromochloromethane extinguisher, one quart size, and (4) a standard carbon dioxide extinguisher, four pound size. The extinguishers were charged with the agents indicated. The bromotrifluoromethane extinguishers used in these tests were test units fabricated by Walter Kidde and Company, Inc., procured for the purpose of service evaluation of the agent as well as for the purpose of testing the extinguisher design.

Actual extinguisher design and development have been conducted in cooperation with leading fire extinguisher manufacturers, and various designs have been tested in the field. This phase of the development program is still in progress.

Paralleling the nominal one quart extinguisher development in many respects, is the program on the utilization of Halon 1301 in 15 and 50 pound capacity fire extinguishing units. In this program both the evaluation and design phases to date have been carried out at the Engineer Research and Development Laboratories. One of the most difficult problems in the application of Halon 1301 in this range has proved to be the design of an efficient nozzle giving the desired discharge stream. Various discharge rates have been evaluated. Table No. 4 shows the results of a series of tests using an extinguisher with a nozzle giving about ½ pound per second discharge of Halon 1301. This extinguisher is compared to several other extinguishers using halogenated agents and carbon dioxide.

Table No. 5 shows a comparison of a nozzle delivering almost one pound per second of Halon 1301 and a commercial dry chemical type extinguisher. In this test an 85-inch diameter tub was used containing water on which 10 gallons of gasoline were poured, giving a freeboard of 10 inches.

Subsequent to the tests reported in Table 5, additional tests were conducted with a second high rate discharge nozzle using Halon 1301 to determine if the test results were influenced by the depth of fuel in the seven foot tub fire. Both 10 and 50 gallons of gasoline were used and the 50 gallon tests gave a fuel depth of essentially 2 inches, the fuel depth now proposed for tests in the proposed reclassification system for fire extinguishers.[10] The results obtained indicated no significant variation of results.

Field Charging Equipment

In this program field charging equipment is being designed such that recharge of the extinguishers may be made at military depots directly from Halon 1301 shipping cylinders.

[10]See NFPA Advance Reports to the 57th. Annual Meeting, 1953, pages 205-209.

* In conducting these tests 5 gallons of gasoline were spilled on a concrete slab in a path approximately 3 ft. wide and 25 ft. long. A twenty second preburn was allowed before extinguishment was attempted.

Table No. 5

Engineer Research and Development Laboratories

Comparison Tests on Seven Foot Tub Fire* Using Bromotrifluoromethane (Halon 1301) and Commercial Dry Chemical Extinguisher

Halon 1301 Discharged at Approximately One Pound Per Second

Agent	No. of Fires	Weight of Agent Used (Averaged) lbs: oz	Extinguishment Time (Averaged) seconds
Bromotrifluoromethane (Halon 1301) using high velocity nozzle	8	5:15	7.1
Dry chemical (20 pound commercial extinguisher)	5	15:03	9.6

*Tests were conducted using a tub 85.2 inches in diameter containing 10 gallons of gasoline floated on water. The freeboard was 10 inches. Although tests were conducted using all vaporizing liquids and mixtures shown in Table No. 4, only dry chemical and Halon 1301 effectively extinguished this fire.

The next step in this program is the field testing of extinguishers and the charging apparatus.

Further investigation of the vaporizing liquids is anticipated in connection with the use of a "knock-down" agent in Army fire fighting equipment for Army aviation and in installations of fixed fire fighting systems for combat type vehicles. This latter study will fall under the cognizance of the Ordnance Corps rather than the Corps of Engineers.

Part VI

Research by the Bureau of Aeronautics[11]

Department of the Navy

By Arthur V. Stamm, Head, Airborne Tankage and Fire Protection Section

This article reports on the Navy's reasons for the selection and intended use of the fire extinguishing agent bromotrifluoromethane (Halon 1301) in aircraft fixed fire extinguishing systems.

Carbon dioxide was the first fire extinguishing agent to become generally used in Naval aircraft fixed fire extinguishing systems. Such systems were used by the Navy in only the larger type multi-engine aircraft. The next agent to be used in similar type aircraft was methyl bromide (Halon 1001). The primary reason for using methyl bromide was to effect a weight saving of approximately 35 per cent over a carbon dioxide system of equal effectiveness. Methyl bromide, as is generally known, is a highly toxic agent; however, in consideration of the remoteness of fixed installations in multi-engine aircraft as related to inhabited spaces, the risks were considered by the Navy to be minimized and no serious incidents have occurred. When it became apparent, however, that fixed fire extinguishing systems would also be used in some Navy carrier type aircraft, it was necessary to choose a less toxic fire extinguishing agent.

[11]For background data, see NFPA Aviation Bulletin No. 87 available from the Association for 25 cents per copy.

Navy Selects Bromotrifluoromethane

The factors which led the Navy to the selection of Halon 1301 for aircraft fixed fire extinguishing systems, are as follows:

TOXICITY. Accidental discharge of the fire extinguishing system during carrier operations and particularly while the aircraft is on the hangar deck must be recognized as a possibility. This means that personnel could be exposed to the agent under many possible conditions. This factor, along with consideration of the products of decomposition of the agent when used to extinguish a fire, imposed a requirement that the least toxic agent must be used that is otherwise satisfactory. Research reported elsewhere in this article indicates that Halon 1301 is the least toxic agent that could be considered. Dibromodifluoromethane (Halon 1202) is slightly more toxic than bromochloromethane (Halon 1011).

EFFECTIVENESS. Halon 1301 and Halon 1202 are essentially equal in effectiveness to methyl bromide as a fire extinguishing agent. Bromochloromethane (Halon 1011) is slightly less effective than either of these agents. All are suitable for use at temperatures from +160°F to −65°F, although Halon 1301 is more effective than Halon 1202 at −65°F.

CORROSIVE EFFECTS. None of these agents present corrosive problems insofar as the metals commonly used in Naval aircraft fire extinguishing systems are concerned. Corrosion-resistant steel is used in extinguishing systems located in aircraft fire zones; outside fire zones, magnesium tubing protected against corrosion or corrosion-resistant steel is used in methyl bromide systems. Aluminum is not used in the system design in Naval aircraft where contact with methyl bromide is possible. Bromochloromethane has never been used in Naval aircraft; however, the same materials used in the methyl bromide system would be utilized in a bromochloromethane system. This utilization of metals in the methyl bromide system has proven satisfactory in service and is considered the lightest weight system possible consistent with good design practice. Accordingly, it was considered that no corrosive problems would arise with this combination of materials in contact with Halon 1301 or Halon 1202 since preliminary investigations indicate that they are noncorrosive to common metals. Aluminum alloy parts and tubing can be used in contact with Halon 1301 in locations outside of fire zones.

WEIGHT AND SYSTEM DESIGN. By utilizing materials as noted above, there would be no appreciable change in weight of a fire extinguishing system using either methyl bromide, bromochloromethane or Halon 1202. The work of the CAA Technical Development and Evaluation Center on a "high rate discharge system" (see Part III herein) for which the more volatile agents carbon dioxide and Halon 1301 are particularly suited, indicates that this type system would weigh less than the conventional methyl bromide system since the nozzle ring and some plumbing could be eliminated and less agent would be required. This simplified extinguishing system would probably cost less than the conventional system. Full scale fire tests are continuing and the results of this work will be summarized and published by the Civil Aeronautics Administration.

AGENT AVAILABILITY AND COSTS. Methyl bromide and bromochloromethane are commonly available materials that cost in the order of $.55 per pound. Halon 1301 can be readily obtained; one manufacturer maintains a supply of 5,000 pounds and can supply 20,000 pounds in a month to six weeks. Several 1,000 pound lots would cost in the order of $4.00 per pound and volume production could bring the price under $2.00 per pound. This agent is also suitable for use as a low temperature refrigerant. Availability of Halon 1202 would be comparable to bromotrifluoromethane; however, the cost would be approximately $6.00 per pound.

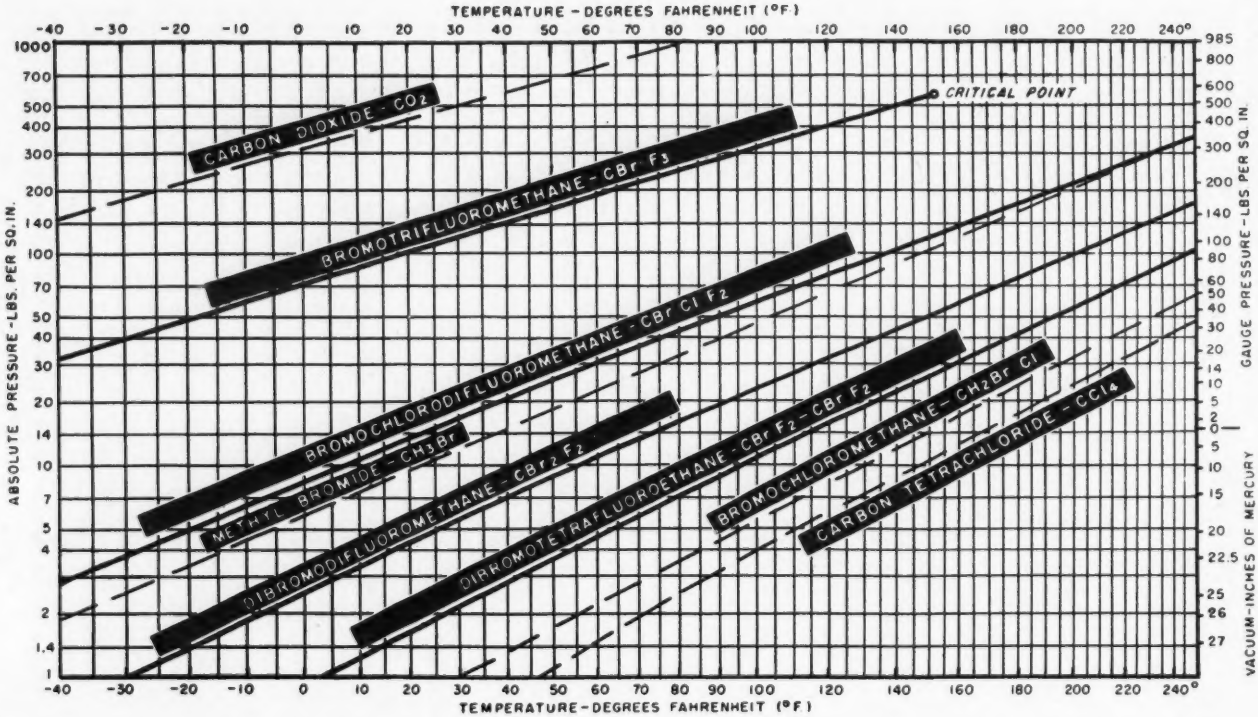

TEMPERATURE - DEGREES FAHRENHEIT (°F.)
-40 -30 -20 -10 0 10 20 30 40 50 60 70 80 90 100 120 140 160 180 200 220 240°
ABSOLUTE PRESSURE - LBS. PER SQ. IN.
1000 700 500 400 300 200 140 100 70 50 40 30 20 14 10 7 5 4 2 1.4 1
GAUGE PRESSURE - LBS PER SQ. IN.
985 800 600 500 400 300 200 140 100 80 60 50 40 30 20 14 10 5 2 0 5 10 15 20 22.5 25 26 27
VACUUM - INCHES OF MERCURY
CRITICAL POINT
CARBON DIOXIDE - CO2
BROMOTRIFLUOROMETHANE - CBr F3
BROMOCHLORODIFLUOROMETHANE - CBr Cl F2
METHYL BROMIDE - CH3Br
DIBROMODIFLUOROMETHANE - CBr2 F2
DIBROMOTETRAFLUOROETHANE - CBr F2 - CBr F2
BROMOCHLOROMETHANE - CH2Br Cl
CARBON TETRACHLORIDE - CCl4
TEMPERATURE - DEGREES FAHRENHEIT (°F.)

Figure 5. Pressure-temperature relationships of some fire extinguishing agents including Halons 1301 ($CBrF_3$), 1211 ($CBrClF_2$), 1202 (CBr_2F_2), and 2402 ($CBrF_2$—$CBrF_2$) with comparison data on carbon dioxide, methyl bromide, bromochloromethane and carbon tetrachloride.

Part VII

Research by E. I. duPont de Nemours & Co.

By Edmond G. Young, Manager, Sales Development, "Kinetic" Chemicals Division

Since the report by Drs. R. C. Downing and B. J. Eisemen, Jr., of the Jackson Laboratory in the NFPA QUARTERLY in October 1951 (Part I), there has been considerable work conducted in our laboratories to further develop the necessary properties of these compounds which are important in their application as fire extinguishing agents.

It has been the purpose of this work to determine the basic physical and chemical properties of the agents. A subsequent report will be made concerning the study of the physiological properties, which work is now being conducted for us at the Underwriters' Laboratories in cooperation with the Medical School of Northwestern University.

The present state of the art of fire extinguishment by use of these agents has been conducted by others and this work is reported in other Parts of this article and in Part II of the 1951 text.

The duPont Company efforts in this field have been to provide the fire protection engineer with fluids which he can intelligently apply to the design of fire extinguishing equipment rather than to furnish fire protection engineers with chemical compounds for which he must improvise application techniques. It is not our purpose here to report the final answers in all the essential properties but rather to record the present state of information which is considerably advanced over that of three years ago.

The four fire extinguishing agents to be covered are as follows:

Compound	Halon No. Designation	Chemical Formula
Bromochlorodifluoromethane	Halon 1211	$CBrClF_2$
Dibromodifluoromethane	Halon 1202	CBr_2F_2
Bromotrifluoromethane	Halon 1301	$CBrF_3$
Dibromotetrafluoroethane	Halon 2402	$CBrF_2-CBrF_2$

Although there has been some information reported previously, more recent work has shown that some of these data were in error. In addition, the full information on the critical properties of these agents, the solubility relationships between these agents and nitrogen, water and carbon dioxide, the viscosities of both the liquid and vapor, the thermal

Table No. 6
Research by E. I. duPont de Nemours & Co.
Basic Physical Properties of Selected Halogenated Extinguishing Agents

	Halon 1211	Halon 1202	Halon 1301	Halon 2402
Chemical Formula	$CBrClF_2$	CBr_2F_2	$CBrF_3$	$CBrF_2-CBrF_2$
Molecular Weight	165.4	209.8	148.9	259.9
Boiling point °F.	25.	76.1	− 72.0	117.5
Freezing Point °F.	−257.	−222.9	−270.4	−166.8
Liquid Density at 70°F. g/cc	1.83	2.28	1.567	2.16
lbs./gal.	15.3	19.0	13.07	18.0
Liquid Density at 130°F. g/cc	1.70	2.15	1.243	2.05
lbs./gal.	14.2	18.0	10.38	17.1
Critical Density g/cc	0.713	0.844	0.745	0.790
Critical Temperature °F.	308.8	388.7	152.6	418.
Critical Pressure lbs./sq. in. gauge	580.	585.	560.	495.

Figure 5. Pressure-temperature relationships of some fire extinguishing agents including Halons 1301 ($CBrF_3$), 1211 ($CBrClF_2$), 1202 (CBr_2F_2), and 2402 ($CBrF_2$—$CBrF_2$) with comparison data on carbon dioxide, methyl bromide, bromochloromethane and carbon tetrachloride.

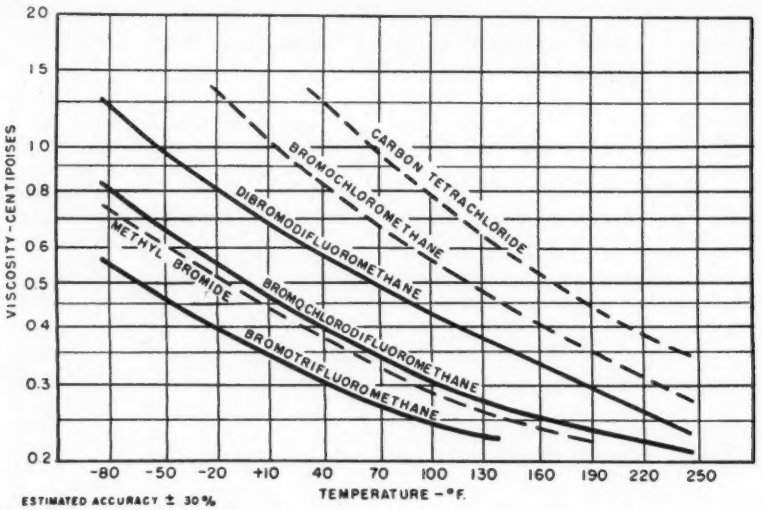


Figure 6. Estimated liquid viscosities of Halons 1202 (CBr_2F_2), 1211 ($CBrClF_2$) and 1301 ($CBrF_3$) with comparison data on carbon tetrachloride, bromochloromethane and methyl bromide.

conductivities, the surface tensions, and the specific heat ratios are all now well understood. Although there is some duplication from Table II in Part I of the 1951 report, Table No. 6, given here, shows a listing of many of these fundamental properties of the four agents listed above as they are now understood.

The full vapor pressure temperature relationships have been established and appear in Figure No. 5. Both vapor pressures in pounds per square inch gauge and in pounds per square inch absolute are shown for ease of use. As a comparison, the vapor pressure curves of several of the more common fire extinguishing agents are represented by the light "dash" lines. It is easy to note that there is a halogenated extinguishing agent incorporating fluorine covering almost every range of temperature which is presently covered by the common fire extinguishing agents. Halon 1301 is similar in its behavior to carbon dioxide and, on the opposite end of the scale, Halon 1202 and Halon 2402 are related to carbon tetrachloride and bromochloromethane in properties. Despite the fact that Halon 1301 has much the same general pressure behavior as carbon dioxide, there nevertheless is a considerable weight gain in the cylinders containing Halon 1301, since the latter requires a cylinder to withstand a pressure of only slightly over 200 pounds per square inch while those for carbon dioxide must withstand vapor pressures of approximately 840 pounds per square inch.

The surface tensions of the two liquid agents, Halon 1202 and Halon 2402 are shown in Table 7.

The viscosity data on three of the four agents under study herein have been determined and are shown in Figures No. 6 and 7. Figure No. 6 covers the liquid viscosity range from −76 to +248°F (−60 to +120°C.). Figure No. 7 covers the vapor viscosities over the same temperature range.

Many times in the design of a fire extinguishing system, the ratio of specific

(Continued on page 162)

Table No. 7

Research by E. I. duPont de Nemours & Co.

Surface Tensions of Dibromodifluoromethane (Halon 1202) and Dibromotetrafluoroethane (Halon 2402)

Compound	Temperature °C.	Temperature °F.	Surface Tension Dynes per cm. Observed	Surface Tension Dynes per cm. Calculated from Parachlor
Halon 1202	24.0	75.2	18.1	18.8
	65.0	149.0	12.6	13.2
	100.0	212.0	9.2	9.2
Halon 2402	27.0	80.6	17.8	17.5
	58.0	136.4	13.9	13.9
	97.0	206.6	10.1	10.0

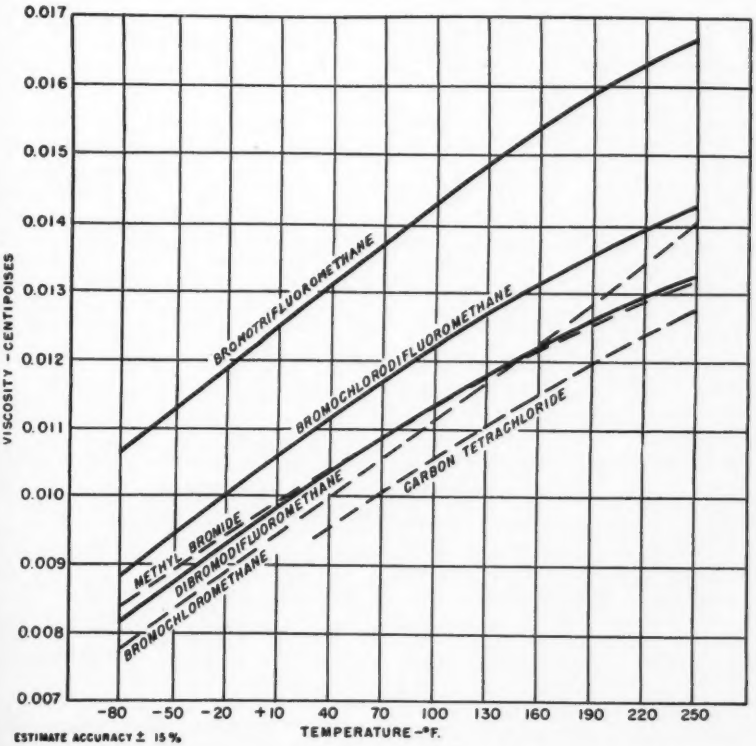


Figure 7. Estimated vapor viscosities at 1 atmosphere pressure for some of the fire extinguishing agents discussed herein including Halons 1301 ($CBrF_3$), 1211 ($CBrClF_2$) and 1202 (CBr_2F_2), with comparison data on methyl bromide, bromochloromethane and carbon tetrachloride.

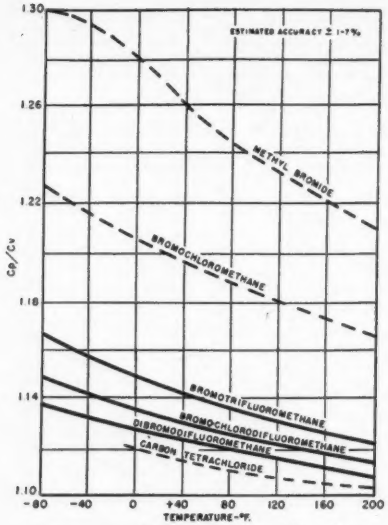


Figure 8. Ratio of specific heats (Cp/Cv) versus temperature at zero pressure for some agents.

heats becomes important. The data we have obtained for the ratio of specific heats varying with temperature when calculated to zero pressure is shown in Figure No. 8. This covers a temperature range from −76 to +200°F. (−60 to +93°C.).

Figure No. 9 shows the thermal conductivities of the liquids. This data is useful in calculations bearing on fixed system installations.

The extent to which the nitrogen pressurizing gas dissolves in the fire extinguishing agents is a design problem in many cases. Due to the wide range of total pressures which may be considered, it is impossible to represent this nitrogen solubility data on a single graph. However, in Figure No. 10, all the essential information is presented to determine the solubility under any given set of conditions. In this Figure, for the various temperatures shown, a solubility constant "k" can be read for each agent. The procedure to find the solubility of nitrogen in the fire extinguishing agent at any particular pressure is to subtract the vapor pressure of the pure liquid at the desired temperature from the total pressure and thus obtain the partial pressure of nitrogen. This partial pressure of nitrogen, divided by the solubility constant "k" read from the proper curve in Figure No. 10, equals the weight per cent of nitrogen dissolved in the liquid phase under these conditions.

If one goes through this calculation under any particular set of conditions which is pertinent to the fire extinguishing application, it will be found that the nitrogen, or air for that matter, is virtually insoluble in all of the fluorinated hydrocarbon agents. This is important in the design of self-propelling extinguishers of the stored pressure type. This factor is not so important for Halon 1301 since, as we have already noted, Halon 1301 has a sufficient pressure in itself to provide for dispensing under normal conditions.

The solubility of carbon dioxide in these agents may be of importance either in consideration of a combined system or for possible use of carbon dioxide as the propelling medium for a stored pressure extinguisher. The carbon dioxide solubility in three of the agents is shown in Figure No. 11. Although data for Halon 2402 is not included, it is reasonable to assume that it will not behave differently than the others.

It can readily be noted that the solubility of carbon dioxide in these agents is markedly higher than for nitrogen. This is of primary concern in the design of stored pressure extinguishers. Relatively larger quantities of carbon dioxide will be used over nitrogen but the pressure drop during discharge will not be as severe with carbon dioxide due to this greater solubility.

The solubility of Halon 1301 was determined in water. Although only this one agent was used in this test, it is believed that the other agents are not significantly different. Since certain minimal quantities of water are almost always present in extinguishers, it is of importance to understand if this water shall be

(Continued on page 165)

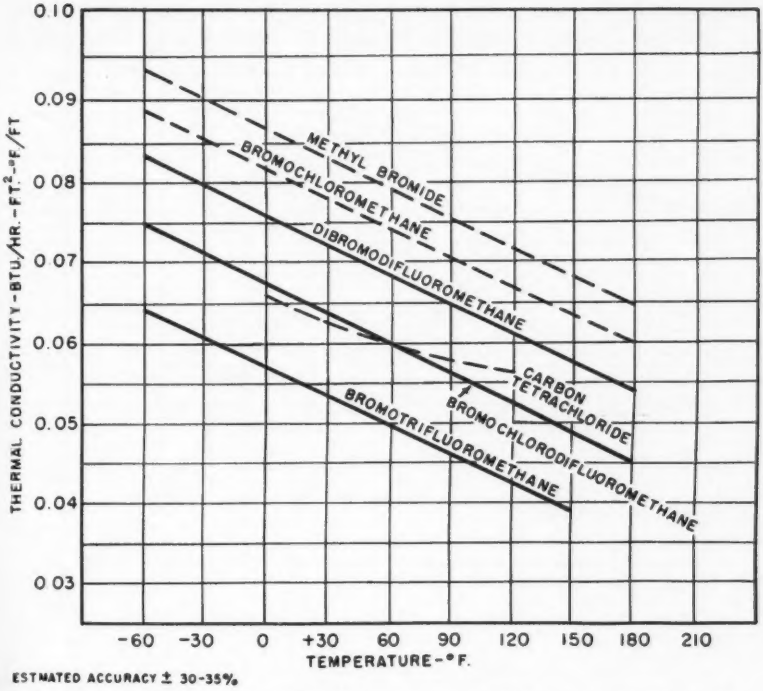


Figure 9. Estimated or reported values for the liquid thermal conductivity of Halons 1202 (CBr_2F_2), 1211 ($CBrClF_2$) and 1301 ($CBrF_3$) with comparison data on methyl bromide, bromochloromethane and carbon tetrachloride.

Table No. 8

Research by E. I. duPont de Nemours & Co.

Swelling of Elastomers in Fire Extinguishing Agents
Per Cent Increase in Length, Maximum (Room Temperature)

Elastomers	Fire Extinguishing Agents				
	Halon 1211	Halon 1202	Halon 1301	Halon 2402	Bromochloromethane
Hycar OR-15	4.8	11.1	0.6	6.8	49.3
Perbunan 26	10.1	22.9	0	10.0	50.4
Neoprene Type GN-A	13.0	26.7	0.2	6.0	34.1
Hypalon E-7	7.2	29.0	2.3	9.8	40.0
GR-S	14.6	24.0	1.0	15.2	26.3
Natural Rubber	23.4	34.1	1.3	26.0	31.5
Butyl	2.3	47.0	2.0	24.0	14.7
Thiokol FA	4.1	7.9	0.3	4.0	*
Silicone 23	14.9	36.3	21.5	33.3	14.4

*No measurement possible — test pieces disintegrated.

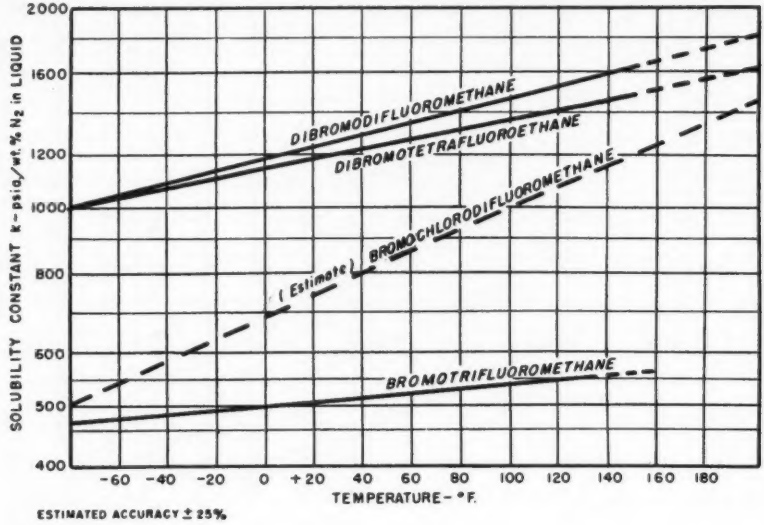


Figure 10. Solubility of nitrogen in Halons 1202 (CBr_2F_2), 2402 ($CBrF_2$—$CBrF_2$), 1211 ($CBrClF_2$) and 1301 ($CBrF_3$).

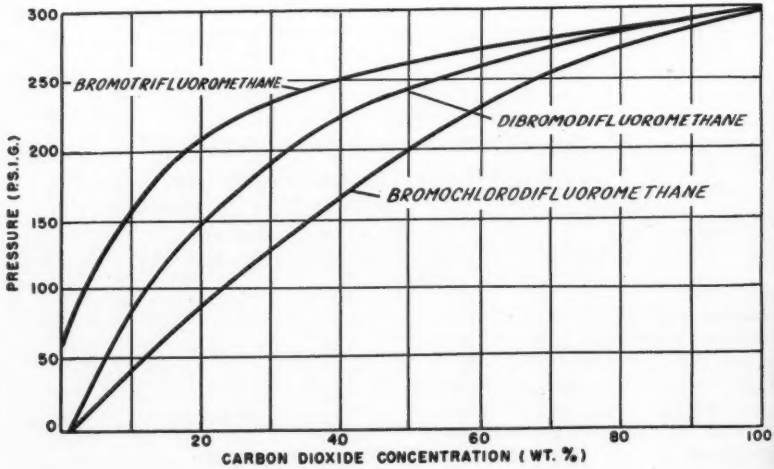


Figure 11. Solubility of carbon dioxide in Halons 1301 ($CBrF_3$), 1202 (CBr_2F_2) and 1211 ($CBrF_2$—$CBrF_2$).

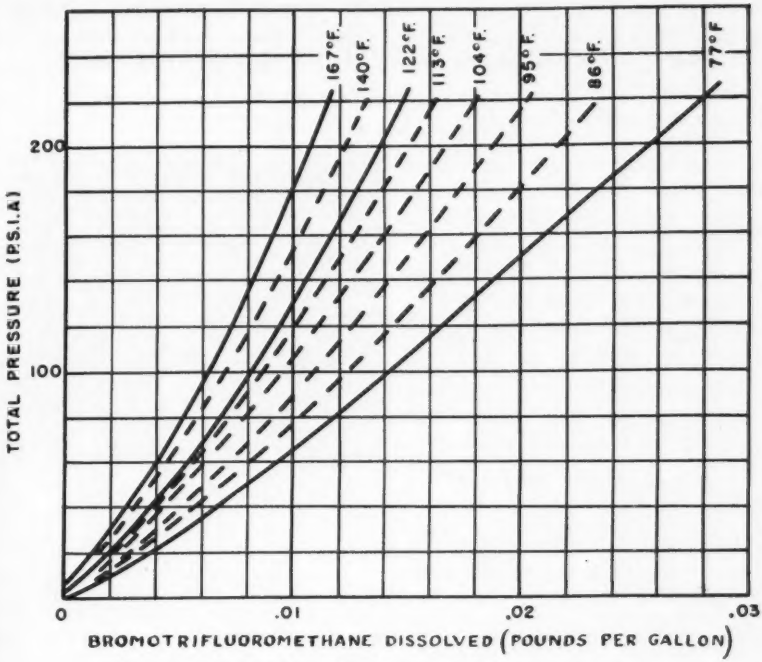


Figure 12. Solubility of Halon 1301 ($CBrF_3$) in water.

dissolved and carried throughout the unit or whether it shall exist as a separate liquid phase thus isolated in the system. The data given on Figure No. 12 show clearly that the water will exist predominantly as a separate liquid phase and therefore may cause local corrosion only.

One new and important chemical property of these fire extinguishing agents has been learned since the last report. This has reference to the attack of the agents on various elastomeric materials which might be used for gasketing. This information appears in Table No. 8, where the attack is represented by the per cent increase in length of a standard test strip. It will be noted that the conditions for this test are room temperature and the test has been run a sufficiently long time so the maximum change is represented.

It is well to point out that not all of these agents can be used indiscriminately with all manner of gasketing materials. Certain of the agents, particularly Halon 1202, have deleterious action on some of the gasketing materials which may be used. It is apparent, however, that appropriate materials can be chosen. It is noteworthy that Halon 1301 can be used most easily. Bromochloromethane is included in this chart for comparative purposes only.

It is the intention of our laboratory to continue work to fully explore all the properties of these interesting compounds. We shall be anxious to be advised of the requirements of any of those who are planning application work with these products. Some of the properties reported herein are either rough experimental properties or else calculations based on analogous materials. It shall be our purpose to confirm these values experimentally by our future work.

Reorganizing A City Fire Department*

By Chief Lewis A. Marshall

Providence Fire Department

In 1943, the officers of the Providence (Rhode Island) Fire Department began thinking of ways to reorganize and modernize their organization. With the end of World War II, some carefully developed plans were formulated and by 1947 action was commenced. In 1951 the essential elements of the plans had been completed and now, in 1954, the reorganization is judged successful by virtue of the following principal, tangible results:

(1) Savings of an estimated $300,000 per year (cost: $1,750,000).

(2) Nine new stations constructed.

(3) Twenty-three old stations abandoned (7 retained).

(4) Number of fire companies reduced by eight (37 companies before reorganization, 29 after).

(5) Twenty-two new pieces of fire apparatus purchased since 1942.

(6) New vocalarm and radio communication system.

(7) More men at fires per individual company.

(8) Completely new inspection districts with company responsibility.

(9) Creation of a reserve or second fire department through use of replaced and off-duty men.

(10) Establishment of a Division of Training with five schools.

(11) A more effective fire prevention program.

(12) A merit promotion system for advancement in the department.

*Based on an address by the author at the 58th NFPA Annual Meeting held May 17-21, 1954 at Washington, D. C.

Chief Marshall as he addressed the NFPA Annual Meeting in Washington.

A continuing reduction in building fires and losses presents the happiest evaluation of the reorganized fire prevention and protection services of the Department and, in addition, morale is improved, disciplinary problems have been reduced and working conditions are better.

It is customary to think of increasing fire department efficiency by such methods as improved personnel recruiting, better standards of officer selection, intensified training and drilling. The fact is that many, if not most, of the fire departments in the country today could increase their efficiency to a marked degree by a reorganization of the physical plant and reconstitution of the department. In fact any city in which station locations have not been surveyed in the last thirty years is probably inefficient in operation for this reason, if for no other. These observations are based on personal experience resulting from the reorganization in my own Department during the past decade.

The PFD reorganization fell into three general phases: First, relocation of fire stations, abandonment of some old stations and the construction of some new facilities, plus the reconstitution of departmental units to eliminate those in excess of the number required to give adequate protection to the community. Second, a revision of the communication systems to assure modern efficiency and effective operational control. Third, more effective utilization of manpower.

Dots on map indicate location of engine and ladder companies in Providence. The revised distribution reduced the number of stations from 30 to 16 and yet maintained adequate coverage. This map is posted over the Communications Control Panel as shown in the photo on Page 172.

Elimination of Stations, Companies

The extinguishing force of the Providence Fire Department formerly totalled 37 engine and ladder companies. By implementing the reorganization program, this was reduced to 29 companies.

Thirty stations were required in the past to house the 37 companies. The number of stations has now been reduced to 16. Thus, 8 companies and 23 old stations have been eliminated.

The excessive number of operating units had led to a fundamental inefficiency because of undermanning of each company. By eliminating the 8 companies, 84 men were available to distribute to other companies. Thus today, each company responding to a fire can have five or six men. It seems better indeed to have two companies responding to an alarm, each with five or six men, than four companies with only two aboard each piece.

Station locations based on horse-drawn days are also fundamentally inefficient. They should be located on main arterial highways and authorities selecting the location should take into consideration the fire incidence of the neighborhood.

There should be no loss in fire protection by such reorganizations and relocations. Applying the National Board of Fire Underwriters' distribution standards* before the reorganization, it was discovered that two-thirds of the city's area was overlapped by the service units of two or more engine companies and, in the high value districts, the overlap was as much as eight times. The selection of station sites appears to be better now because the city is still in full compliance with NBFU standards and at the same time the revised locations are based on what there is to burn and what has been burning. A statistical study of the fire record data over a period of years aided in selecting the new station sites.

It is recognized that in any community, there are individual buildings or general structural conditions where all the companies required for distribution might be needed and, perhaps, even all would not be sufficient. For cities over 200,000 population, fire equipment distribution must provide for ready concentration and should not strip nearby areas of protection in case of a second fire. Approximately sixteen pumpers must be available within three miles of the congested value districts.

The new stations built are modern, fire-resistive structures set back from traffic lanes to permit safe and prompt egress of equipment. The apparatus floors are open, free from obstructions, and designed to provide ample room for reserve apparatus which is utilized by off-duty men under a permanent, predetermined and systematic plan for reinforcing the department during multiple alarms or other emergencies. The stations are equipped with automatic controls for heating plants, apparatus doors and night lights as well as being protected by traffic warning signals. Many of the older stations were found suitable for continued use as company quarters and are reasonably well located to meet the particular coverage demanded by adjacent areas. For obvious economic reasons, such stations were retained. The locations of the new stations were predicated upon the full utilization of the cov-

*NBFU standards specify that response limits for engine companies in high valued districts should not exceed ¾ mile, 1½ miles in built-up residential districts and 3 miles for scattered buildings. For ladder companies, comparable limits are 1, 2 and 3 miles.

One of the new stations built by the Providence Fire Department on North Main Street. Note width of driveway which gives apparatus easy access to highway.

erage provided by companies housed in the retained stations.

Revision of Communications

The new communication system has been placed under a newly created Division of Operational Control in charge of a Battalion Chief, designated as Chief Dispatcher. Any department which has two-way radio knows that company utilization can be increased 50 or 60 per cent. The Providence Fire Department experience is similar but we are making additional use of the improved communications in connection with our fire prevention program.

With radio, all companies, on prearranged schedules, go on fire prevention inspections and respond to fires from the inspection sites. In setting up this procedure, the Fire Department worked with the Retail Board of the Chamber of Commerce. Some members of the Retail Board were skeptical about having fire apparatus outside their places of business as they feared it might lead customers outside to think that there was a fire in progress or might make those inside so concerned they might leave the store. This objection was overcome by having a large sign placed on the apparatus saying "Firemen Inspecting Buildings—Respond To Fire By Radio."

Shortly after the nursing home fire in Florida,* a special order was issued for the inspection of all nursing homes and rooming houses in the City. This required considerable time and as a consequence the mercantile inspection program went off schedule. As a result, the Retail Board called and wanted to know what happened; several firms had called them wanting to know where the firemen were! The merchants feel that these fire prevention inspections kept their personnel on their toes!

Of course, there are other benefits derived by these inspections. Firemen in the district become familiar with the buildings, occupancy hazards, sprinkler shut-

*See April 1953 NFPA Quarterly, pages 293 to 300; also available in pamphlet form (NFPA Q46-13, 35 cents per copy).

offs, standpipes, electric meters and gas shut-offs. In the old days with one man inspecting and using a card system, he could spend his time in the boiler room. Now with a company officer in charge, the inspections are done properly and there is opportunity for group discussions. In addition, these radio inspections allow dwelling house inspections in the spring and fall. A great deal of good will is gained from these inspections of private and multiple dwellings.

Another important phase of radio is the speed by which additional equipment can be called to a fire, and the ease with which companies on response, while filling in or while returning from alarms, may be intercepted or diverted. For example, a situation developed last May 12th. Two false alarms occurred in the same area within minutes; one at 1:54 A.M. and the other at 1:57. These were handled by the same companies by radio and resulted in the apprehension of a man in the neighborhood. Today with 75 per cent of our alarms being received by telephone or vocalarm, it is possible to inform companies as to whether they will have to contend with a cellar fire or a fire in a room on the 16th floor of a hotel. Usually a company officer responding to a box alarm will begin to "size up" on leaving the station with information furnished by the dispatcher.

Utilization of Manpower

The basic operating unit in a fire department is the company. Undermanning of the individual company is a more serious deficiency than having inadequate total manpower on duty. There has been a marked increase in multiple alarms in many large cities. Loss figures show that many of these multiple alarms should not

A radio-equipped unit of the Providence Fire Department during an inspection of the Shepard department store. The sign on the side of the truck was provided to assure customers that there was no fire in the property being inspected. Such publicity has had a very favorable public relations effect in the community.

have occurred. There is only one explanation. Individual companies have been so undermanned that the chief officers sound additional alarms, not for equipment but for manpower. This general undermanning of fire departments has come about gradually. It has been due primarily to granting firemen additional time off. Will a city feel the expense of a fire force which has only one-quarter of its manpower on duty? Will this reduced force be adequate for fires of unusual magnitude? There is much wishful thinking that the large fire will not occur. No special attention is being paid to the fact that this undermanning is today making it necessary to send in many multiple alarms which proper company manning would avoid.

Evaluating Manpower Needs

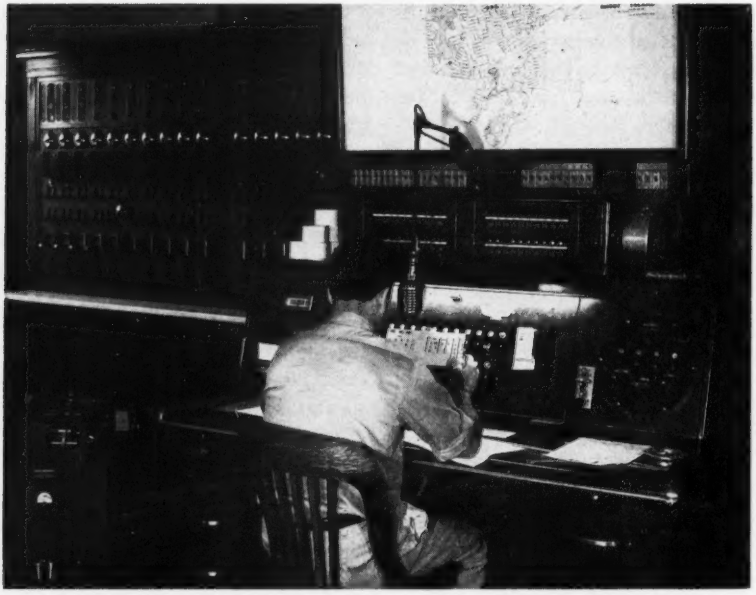
There can be little question that there must be fully manned companies in high value districts to give adequate manpower to advance 2½-inch lines to upper floors. It appears that approximately one out of about every three hundred fires is a serious one. This is usually the result of delayed discovery or a flash fire. About 95 per cent of all fires are handled with extinguishers or one water stream. In determining equipment and manning needs two factors must be considered: (1) The greatest demand for men and equipment that might be needed at any one time, and (2) the minimum number of companies that must be distributed through the city in order to insure an adequate first alarm response. In Providence, by reducing the number of companies and yet retaining the equipment as reserve, we have the same amount of equipment as before. By utilizing the recall system, we have a large reservoir of manpower.

The new response system provides that for any response up to and including a third alarm, units still remain in each section of the city. This is accomplished through bypassing certain intermediate companies. This new response system is called the "block plan" and has eliminated the so-called "slow company" and has spread the work load more evenly. On first alarm box assignments in perimeter and residential areas, responses have been reduced from three engines to two engines, one ladder, one Battalion Chief. For still alarms on building fires, responses have been increased from one company to two engines, one ladder and a Battalion Chief.

On second alarms, the nearest company is the first company to respond. Then we reach out for the second and third due company. On the third alarm the same procedure applies. This system requires no relocation of companies. Companies are dispatched separately and may by-pass other companies which are held so that they can run in either direction if needed. In the high value district, one company is held in every station up to and including a third alarm. On third alarms, off duty men start returning to stations according to prearranged plans. We have fourteen reserve engine companies completely equipped, ready to roll.

To assist the dispatcher, we have a large map equipped with red, green, and yellow lights. The map shows the status of every company in the city and provides a complete picture of the deployment of the fire-force at any time. For any further alarms, he can select the required companies.

Usually, on multiple alarm operations, proportionately as many ladder trucks as engine companies are left in service.



The central despatch desk at fire alarm headquarters in Providence controls the movement of all companies. When the alarm is received a tone signal is used to alert companies which are despatched by vocal instructions confirmed by coded signals. Lights on the map show companies which are in quarters. The dictaphone machine records all messages including telephone alarms.

Therefore, when there is reserve engine apparatus, it is our practice to assign one man from the ladder truck to the reserve engine. If there are five ladder trucks in quarters, a double company is provided consisting of an engine and ladder truck to respond with five or six men to handle both trucks until such time as off duty men respond to handle the reserve engine.

It has been our experience that within thirty minutes to one hour we can have fourteen reserve pumpers and five reserve ladder trucks in service with off duty personnel. As a matter of fact, we are in much better condition under this multiple alarm situation than under normal operating conditions when there are three or four single alarms at the same time.

We created another district, thereby lessening coverage for each Battalion Chief so that we have a "white coat" on the job immediately to direct activities. Without leaving his car he can radio for more help or intercept companies.

With the gradual increase in "time off," there was a general acceptance that there must be an increase in the total number of men to provide adequate manning of individual companies. However, with the reduced work week there is a reserve force of trained officers and men three times larger than the force on duty.

EDITOR'S NOTE: Since May 1954 increased efficiency of fire companies has resulted in eliminating several additional companies and further reducing the working hours for firemen.

Combating Fires Involving Radioisotopes

George G. Manov
U. S. Atomic Energy Commission

Much has been said about the hazards of handling radioactive materials and about the radiation burns and (possible) fatalities that might result because of conflagrations involving radioactive materials. The purpose of this discussion is to attempt to set some of these hazards in true perspective.

It should not be necessary to remind that radioisotopes in themselves are not combustible nor do they give rise to fires because of their radioactivity. For example, radioactive benzene has exactly the same combustible properties as normal benzene. Radioactive carbon tetrachloride has the same fire extinguishing properties as does ordinary carbon tetrachloride.

The excellent safety record in the Atomic Energy Commission installations and in approximately 3,000 off-Commission laboratories using radioisotopes on a smaller scale attests to the fact that radioactive materials, like electricity, toxic chemicals and explosives, can be handled safely if appropriate precautions are employed. Indeed, in many respects, the handling of radioisotopes can be made less dangerous than the handling of such other materials.

It is true, on the other hand, that fighting fires in locations in which radioisotopes are stored or are being used may present some hazards not normally encountered in the conventional type of fire. In evaluating a particular situation, one must consider the quantity of radioactivity involved in relation to the method in which it is stored or used. Medical, academic and industrial laboratories use radioisotopes in amounts which are many times less than those used in AEC installations. Thus, the precautionary measures necessary for an AEC and a non-AEC facility will vary widely.

Recognition of Radiation Hazards

Artificially produced radioactive materials distributed under the AEC Radioisotope Program cannot be purchased over the counter or traded back and forth as with normal commodities, and they are obtainable only upon application to the AEC. Requirements for obtaining such materials involve obtaining appropriate training and experience on the part of the investigator, the possession of adequate survey and monitoring instruments, etc.[1]

Placards are furnished with shipments of radioactive materials and must be displayed prominently in the area where the isotopes are used. These placards are in the form of yellow background on which there is a magenta propellor-type insignia as shown in Figure 1. Appropriate warnings in large letters appear on the yellow background and a space is provided on

The information in this paper was prepared by Dr. Manov for a conference, December 9, 1953, sponsored by the Safety and Fire Protection Branch, D. F. Hayes, Chief, for fire protection engineers of AEC offices.

[1] Radioisotopes can be purchased from secondary suppliers but the AEC requirements above must be met before the sale can be authorized by the AEC.

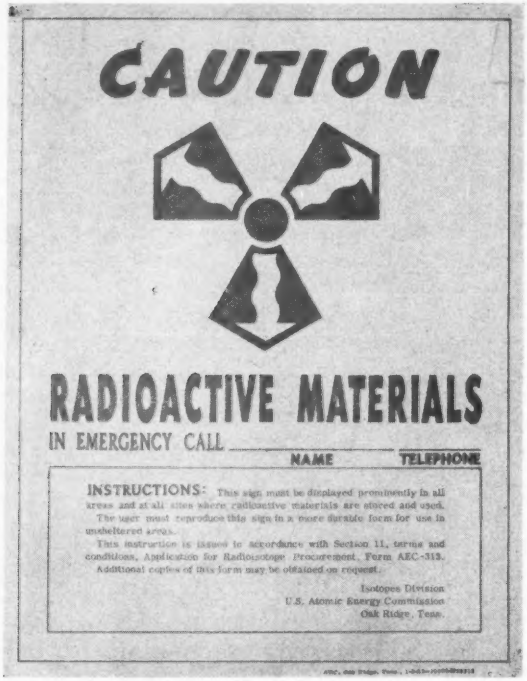

CAUTION
RADIOACTIVE MATERIALS
IN EMERGENCY CALL
NAME
TELEPHONE
INSTRUCTIONS: This sign must be displayed prominently in all areas and at all sites where radioactive materials are stored and used.
The user must reproduce this sign in a more durable form for use in unsheltered areas.
This instruction is issued in accordance with Section 11, terms and conditions, Application for Radioisotope Procurement, Form AEC-313. Additional copies of this form may be obtained on request.
Isotopes Division
U.S. Atomic Energy Commission
Oak Ridge, Tenn.

Figure 1.

which to indicate the kind of isotope, the approximate level of radiation, and the name and address of the radiation safety officer to be notified in case of trouble.

The AEC distributes lists of its radioisotope users to the agency responsible for health and safety in each state. These lists contain the name and address of the isotope user, together with the quantity and kind of material shipped. While these lists are not intended for general distribution, they may be reproduced by the state agency for the proper conduct of its business. It would be worthwhile for fire department heads to become familiar, through the appropriate state agency, with the location of large sources of radiation. This practice is identical to indicating on a city map, for example, the presence of large quantities of gasoline or other flammable liquids. If fire breaks out in a laboratory in which radioisotopes are or may be involved, the fireman seldom, if ever, encounters the situation "blind." Previous knowledge of the major locations of radioisotopes in his area and the presence of the yellow warning sign should tell him of the existence and the magnitude of possible hazards.[2]

[2] Because the AEC has no jurisdiction over naturally-occurring radioactive materials, such as polonium, radium, etc., the location of such materials should be obtained from the cognizant state group, for example, the Bureau of Industrial Hygiene or its equivalent.

Wherever a situation is likely to exist in which firemen may be called upon to enter a building containing large quantities of radioactivity, it is not inconceivable that such firemen should be equipped with radiation-detection film badges and preferably a radiation measuring instrument of some type (see Reference 1 at end of this article). As the Civil Defense program grows, perhaps more and more fire stations will be equipped with such instruments.

Principles of Protection

Radioactive atoms are "brothers" of ordinary atoms with the difference that the former give off atomic radiation.[3]

Differentiation of the radiation hazard involved should be made along two lines: (a) that which falls upon the body from the outside or upon a smaller portion of it, and (b) that which occurs from within the body, as when radioactive material is accidentally ingested. Basically, therefore, one needs protection against (a) external and (b) internal radiation.

Protection against external radiation is obtained by reducing as much as possible the *quantity* of radioisotopes used, by maintaining a suitable *distance* from the source and by remaining in the radiation area for as short a *time* as possible. Protection against internal radiation can be effected by the suitable use of respirators containing especially prepared cellulose-asbestos filter pads[4] or by using selfcontained breathing apparatus.

Protection from External Radiation

External protection from the radiation hazard from isotopes that emit alpha, beta and/or gamma radiation is essentially limited to a problem of protection against gamma radiation, because the alpha and beta components can be screened out with a rather small thickness of protective material.

The accepted permissible limit for whole body exposure to gamma radiation, as set by the National Committee on Radiation Protection (see Reference 2, 3), is 300 mr[5] in any week. The time required

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[3] Four types of radiation may be involved: alpha, beta, gamma, and neutron. Alpha radiations (ionized helium atoms) are stopped by a thickness or two of paper. Beta radiations (high speed electrons) are more penetrating and they may require up to as much as one-half inch of plastic or other light shielding to stop them completely. Gamma (electromagnetic) radiations are much more penetrating and generally require the use of lead or concrete shielding, the quantity needed depending upon the intensity of the radiation initially present. Neutrons penetrate most matter, but are absorbed readily by water and by certain metals.

[4] These respirator pads are available commercially from the Mine Safety Appliances Company, Arthur D. Little Company, Camridge Corporation, and elsewhere, under the generic name "absolute filter."

[5] Radiation dosage is measured in units known as roentgens. Since this unit is quite large, a smaller unit known as a milliroentgen (mr) is commonly used. 1,000 mr = 1 roentgen. The 300 mr/week limit set by the National Committee for Radiation Protection was adopted by Federal Civil Defense Administration (see Reference 4) for training activities. In an *emergency,* FCDA states that "exposure of 25 R (25,000 mr) per day at weekly or longer intervals for a total of 8 exposures, 200 R (200,000 mr) may be experienced without loss of efficiency . . ."

[6] The unit used for measuring the quantity of radioactivity is known as a curie. A curie of an isotope is that amount which will emit radiation at the same rate as 1 gram (one-twenty-eighth of an ounce) of radium. While most isotope sales to date have involved millicurie (mc) or microcurie amounts, a few shipments involving as much as 1,000 curies have been made (1 curie = 1,000 mc = 1,000,000 microcuries). The actual weight of radioisotopes in individual shipments is generally a very small fraction of an ounce.

[7] The energy with which radiations are emitted by individual isotopes may be found in many reference books such as NUCLEAR DATA, National Bureau of Standards Handbook No. 499. Radiation energy is measured in units of million electron volts (MEV).

to receive a 300-mr radiation dosage during a single exposure to an unshielded radioisotope emitting gamma radiation may be computed from the formula:

$$T = \frac{50\ d^2}{(mc) \times MEV}$$

where T = Time in hours required to receive a 300-mr dosage from an unshielded gamma emitting radioisotope.

mc = Quantity of radioisotope in millicuries[6]

MEV = Energy of gamma radiation in million electron volts[7]

d = Distance in feet between unshielded radioisotope and person receiving radiation exposure

Example: Cesium-137, an isotope presently used for radiography of metal castings, has a gamma ray energy of 0.6 MEV. How long would it take each of two people, 1 foot and 5 feet away, respectively, from a 100-mc quantity of unshielded cesium-137 source to receive 300 mr (the maximum permissible dosage during any single week)?

(a) At 1 foot from an unshielded 100 mc source of cesium-137:

$$T = \frac{50 \times 1^2}{100 \times 0.6} = \frac{50}{60} = 0.84 \text{ hours (or 50 min.)}$$

(b) At 5 feet from an unshielded 100 mc source of cesium-137:

$$T = \frac{50 \times 5^2}{100 \times 0.6} = \frac{1{,}250}{60} = 21 \text{ hours}$$

The simplest method of protection is to maintain *distance* between the source and the person. It is known that doubling the distance between the source and the recipient reduces the radiation intensity received to one-quarter of the previous value; tripling it reduces it to one-ninth, etc. Therefore, if one maintains a 10-foot distance between the source and the recipient, the radiation received by the body will be one-hundredth that of the person initially standing only 1 foot away.

The second method of reducing exposure to radiation is to use suitable *shielding*. For this purpose lead, concrete, etc., are commonly applied. Sources larger than a few millicuries which emit gamma radiation are generally stored in lead or concrete vaults with thicknesses sufficient to reduce the radiation intensity to a permissible value.

Generally speaking, therefore, the hazard of obtaining an intense internal radiation burn from a source of radioisotopes is rather small. Modern lead storage containers are designed to incorporate an outer steel container surrounding the lead shielding. The possibility of standardizing suitable types of shipping containers affording increased resistance to fire exposure is currently being considered.

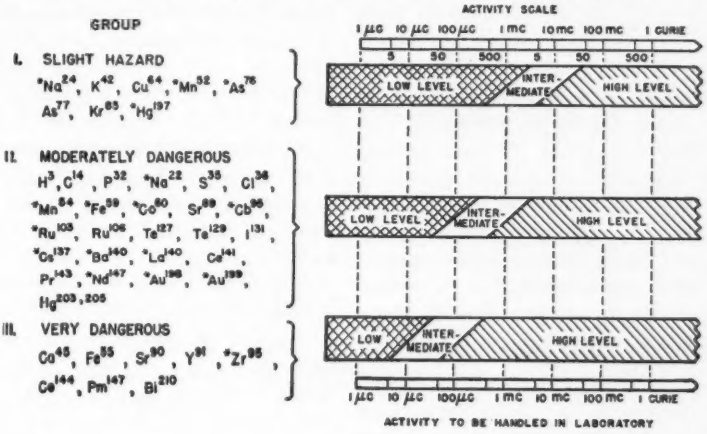
Larger units of radioactivity such as sealed teletherapy sources may have as much as 1,000 curies or more of radiocobalt or radiocesium properly shielded to reduce the radiation to a permissible value. These devices are required to be installed in concrete rooms that are fire resistant, except possibly for an examining table on which the patient may recline. The possibility of obtaining excessive radiation exposure here appears to be rather low, but once again the fireman should adequately inform himself of the existence of such potential hazards.

Of somewhat more concern, however, would be fires involving laboratories or installations not using sealed sources, for example, manufacturers of Strontium-90 markers, etc. Once more, firemen should have received ample warning in the form of radiation-safety signs (see Figure 1) and in the knowledge of the location of such materials. Satisfactory respirators are available, as previously indicated.

[6,7] See page 175.

HAZARD FROM ABSORPTION INTO THE BODY

Selected radioisotopes grouped according to relative radiotoxicity, with the amounts considered as low, intermediate, or high level, in laboratory practice.



NOTES

Effective radiotoxicity is obtained from a weighting of the following factors:

Half-life.
Energy and character of radiations.
Degree of selective localization in the body.
Rates of elimination.
Quantities involved and modes of handling in typical experiments.

The slant boundaries between levels indicate border-line zones, and emphasize that there is no sharp transition between the levels and the associated protection techniques.

The principal gamma-emitters are indicated by asterisk (e. g., $*Na^{24}$). The above level system does not apply to the hazards of external irradiation.

Figure 2.

Protection from Internal Radiation

Radioisotopes ingested into the body may present a more serious hazard. In Figure 2 is a listing of radioisotopes in the order of the hazard they present from ingestion. The hazard from any particular isotope is evaluated on the basis of its physical half-life (time to decay naturally to one-half the original activity), the biological half-life (the combination of the physical half-life and the time taken to eliminate or excrete half the radioisotope from the body), and the kind of radiation emitted (alpha, beta, gamma), the energy of the radiation in MEV, and the degree of localization, if any, of the radioisotope within a given tissue or organ. In examining Figure 2, we see, for example, that sodium-24 is listed in the category of "slight hazard," even though it is a very powerful beta and

gamma emitter. On the other hand, it has a short half-life (14 hours), it does not localize within the body and is rapidly excreted. Conversely, Strontium-90 emits only beta radiations, but tends to segregate in the bones and in the blood-forming organs. The rate of excretion is rather small and the physical half-life of the material is about 25 years. Thus, other things being equal, it would be more hazardous to combat a fire in which the same quantity of strontium, rather than sodium-24, was involved. Again, quantity of material present in the laboratory and the type of container in which it is stored will determine the relative degree of hazard.

Firemen who have been exposed to possible radioactive dust, in case of a severe fire involving large quantities of radioactive materials, should take the elementary precaution of monitoring their outer clothing and taking nose swabs, etc., before returning to inactive duty. Particular attention should be given to monitoring the hair, fingernails, nose, wrists and ankles, as well as fire fighting equipment such as hose, hand tools, and extinguishers. A quick examination with a Geiger or other counter will reveal the presence of such contamination. Decontamination procedures are available and have been published by the National Committee on Radiation Protection (see Reference 6).

Maximum Permissible Doses

The maximum permissible external whole body radiation dose has been set at 300 mr/week (Reference 2, 3) on the basis of recurring, continuous exposure throughout the year. On the other hand, the body is a machine enormously capable of self-rejuvenation, and it is possible to receive many times this weekly dose in *single* event without irreversible harm t the tissue. Recent thinking on the sub ject indicates that it may be of the orde of 15 to 25 roentgens (15,000 to 25,00 mr) at a single time. Such a maximu permissible single dose is presently bein considered by the Federal Civil Defens Administration for rescue workers (se Reference 4). This dose would co respond to a fireman standing 1 foot awa from an unshielded 5 curie source o Cs-137 for 1 hour. The probability o one obtaining a dose of this magnitud is rather small in normal firefighting. I addition, if the source were covered b bricks and debris, the radiation intensit will be reduced to the extent of the radia tion absorbed by such covering.

Shipment of Radioisotopes

Several years ago, the Interstate Com merce Commission began to investigat the problem of shipping radioactive mate rials by common carriers. The aid of th National Research Council (see Refer ence 5) was enlisted and a suitable com mittee was set up to make recommenda tions. Today, radioisotopes are bein transported on all the major airlines, o passenger trains, railway express truck etc.

The sensitivity of a photographic emul sion to radiation is many times that o human tissue, and a given amount o radiation will appreciably fog a film lon before that same quantity of radiatio will have any effect on the human body This fortunate situation means that, i the packages containing radioisotopes ar stored or shipped so that the radiatio intensity is not enough to fog film, th passengers and the crew of the carrier wil not be harmed. ICC regulations limit th

radiation intensity at the outside of the package to 10 mr/hour at 1 meter, prescribe the minimum size for such packages, and specify the allowable segregation and the type of enclosures to be employed.

Probability of Fire Departments Encountering Radioisotope Hazards

From data detailed in Appendix 4 of the AEC report entitled "Major Activities in the Atomic Energy Programs," July-Dec. 1953, it will be noted that:

(1) AEC made 42,749 shipments of radioisotopes from 1946 through 1953.

(2) Present radioisotope shipments approximate 1,000 per month.

(3) The 1,858 individual radioisotope users up through 1953 may be classified as follows:

Type of User	*Number*	*Percent*
Industrial	774	41.6
Medical	627	33.7
Colleges	198	10.7
Federal and State	198	10.7
Institutions	47	2.5
Other	14	0.8
Total	1,858	100.0%

(4) About 55 percent of all of the radioisotope users up through 1953 were located in the following seven states: New York (12.9%); California (11.8%); Pennsylvania (7.7%); Ohio (6.2%); Illinois (5.9%); Massachusetts (5.7%); and Texas (5.2%).

(5) Radioisotopes involved in the 10,676 AEC shipments made during 1953 alone are listed in the accompanying table.

AEC RADIOISOTOPE SHIPMENTS 1953

Radioisotope	*Number of Shipments*	*% of Total Shipments*	*Half-Life*	*Maximum Gamma Energy*
Iodine 131	4,559	42.8	8 days	.72 MEV
Phosphorus 32	2,316	21.7	14.3 days	None
Carbon 14	260	2.4	5,720 years	None
Sodium 24	338	3.2	14.9 hours	2.76
Sulphur 35	204	1.9	87.1 days	None
Gold 198	545	5.1	2.7 days	.411
Calcium 45	108	1.0	152 days	None
Iron 55	145	1.3	2.9 years	None
Cobalt 60	190	1.8	5.3 years	1.33
Potassium 42	167	1.6	12.4 hours	1.51
Strontium 89, 90	90	.8	53 days and 25 years	None
Other	1,754	16.4		
Total	10,676	100.0		

NOTE: Half-life and maximum gamma energy figures are from sources other than the July-Dec. 1953 report mentioned. All listed radioisotopes (except iron 55) also emit beta radiation.

(6) During 1953, one or more AEC radioisotope shipments were made to every state in this country.

The above data have been presented in some detail to substantiate several points that are of particular interest to firemen, namely:

(1) Since there were only 1,858 isotope users in the United States and its possessions during 1953 — an average of under 40 users per state—it is obvious that only very few of the municipal fire departments in any state have any current problems involving radioisotopes.

(2) Over 83 percent of the radioisotope users during 1953 were engaged in medical or industrial work. Nearly two-thirds of the shipments involved iodine 131 or phosphorus 32 (both of which were shipped in the form of nonflammable chemical compounds).

(3) Based on previous trends, increased use of radioisotopes, particularly in industrial fields, may reasonably be anticipated in the future. Most of these probably will be in the form of sealed sources.

Summary

Radioisotopes may present an added hazard during firefighting, but not because of any inherently new prop such as increased combustibility, etc. general, the hazards to firefighters not be increased appreciably because radioactivity, although one must l upon radioactivity as one more hazard a normally hazardous business. There warning signs to help the fireman lo radioactive materials, instruments detecting radiation, protective devices his use, and decontamination measu where necessary (see Reference 6).

References

1. Radiological Monitoring Methods and struments, National Bureau of Stand (NBS) Handbook 51.

2. Safe Handling of Radioactive Isoto NBS Handbook 42.

3. Recommendations of the Internati Commission on Radiological Protection, Handbook 47.

4. Emergency Exposures to Nuclear Ra tion: Civil Defense Technical Bulletin, 11-1, March 1952.

5. Problems Associated With the Trans tation of Radioactive Substances. Nati Research Council, Publication 205 of National Academy of Sciences (Note: W this booklet is out of print, it neverthe constitutes one of the most complete stu of the subject published to date).

6. Control and Removal of Radioactive C tamination in Laboratories, NBS Handbook

Fires and Fire Losses Classified, 1953

There were approximately 1,899,400 fires of all types in the United States in 1953, causing a loss of $1,021,720,000. According to estimates compiled by the National Fire Protection Association, the year 1953 was the fifth successive year in which the United States experienced an increase in fire loss.

Building fires in the United States in 1953 totalled 727,000 and caused $889,-120,000 damage. An additional 1,172,-400 fires not involving buildings — aircraft, motor vehicles, forest, ships, rubbish, grass fires, etc.—accounted for an estimated $132,600,000. Building fire estimates for 1952, reported in the October 1953 Quarterly, showed 703,000 fires with a loss of $793,500,000.

It is interesting to note that the number of building fires for 1953 has increased 3.4 per cent over 1952 figures, while the loss of 1953 is 12 per cent more than the previous year. The General Motors fire at Livonia, Michigan, August 12, 1953, accounted for almost one half of this increase. Preliminary estimates by the National Board of Fire Underwriters for the first eight months of 1954 indicated a decrease of approximately 1.8 per cent from the same period of 1953.

The data from which Tables I to IV were compiled were obtained from 20 state fire marshals' reports for the year 1953 or the closest fiscal year thereto. The gradual increase in the number of states that submit Annual Reports is gratifying. This year the Delaware State Fire Marshal submitted the first Annual Report of fire experience for his state.

The 20 state reports used in this tabulation were chosen because they contained the most complete classifications of cause and occupancy data. While the methods of reporting and tabulating fire loss figures differ from state to state, the volume of statistics from these 20 typical states representing all sections of the country, and including both primarily agricultural and industrial states, is sufficiently large to indicate the relative distribution of fires and fire losses. Table I shows the number of fires by occupancy in 16 states and Table II the loss by occupancy in 14 states. Tables III and IV list the number of fires and loss by cause in 17 and 14 states respectively. Table V summarizes state statistics used in compiling Tables I to IV.

Tables VI and VII, showing the nation-wide distribution of fires and losses by occupancy and cause, are based primarily on typical state experience enumerated in Tables I to IV.

Among the notable changes in 1953 experience (as compared with 1952) were a 5.8 per cent increase in the number of dwelling fires, a 25 per cent increase in the number of fires in barns, a 10.5 per cent decrease in the number of warehouse fires, a 6.3 per cent decrease in the number of automobile fires, and an 18 per cent decrease in the number of forest fires. The number of fires caused by defective or overheated chimneys and flues decreased 22 per cent.

Various sources have furnished figures for certain items in Table VI. Railroad losses were furnished by the Association of American Railroads, Fire Protection and Insurance Section. Statistics on aircraft fires were compiled by the NFPA Committee on Aviation and Airport Fire

(Continued on Page 186)

TABLE I. Number of Fires by Occupancies in Sixteen States — 1953

Occupancies	Conn.[1]	Del.	Iowa	Kans.	Ky.[3]	La.	Minn.	Nebr.	N.H.	N.Dak.[2,3]	Ohio	Ore.[2]	S.Dak.[3]	Tex.[2,5]	W.Va.[4]	Wisc.	Totals
I. PUBLIC BUILDINGS																	
Government buildings	1	...	6	1	12	...	2	3	6	50	...	20	7	...	...	16	124
Hospitals, institutions	...	...	14	12	11	38	8	2	2	18i	35	...	1	8	1	40	190
Schools and colleges	9	2	27	16	59	58	22	21	11	8	51	56	7	43	17	133	540
Churches	10	3	19	13	32	34	16	9	7	15	63	39	4	45	10	104	423
Theatres, including motion pictures	4	6	5	8	39	15	11	3	...	4	20	12	7	16	...	15	165
Amusement, halls	14	...	27	18	...	...	15	26	16	...	68	...	...	24	...	90	298
II. RESIDENTIAL																	
Hotels	20	8	58	42b	...	433	77	12	26	35	241	478e	39l	230	16	146	1,861
Boarding and rooming houses	48	16	23a	23a	33	...	...	66g	6	...	...	...	...	45	...	70	330
Apartments	155	177	174	115	...	...	215e	...	40	...	1,550e	...	20	753	19	303	3,521
Dwellings	788	754	1,615	1,305	4,713	3,635	1,124	542	818	690g	5,748	11,303g	394	4,426	649	25,763	64,267
III. MERCANTILE																	
Offices, banks	18	13	56	39	30	...	38	13	...	...	104	...	10	115	16	75	527
Restaurants, taverns	46	27	100	51	112	...	72	18	22	...	...	149	10	270	31	736	1,644
Miscellaneous mercantiles	120	120	248	255	358	386	206	68	69	141	646	585[6]	117	457	66	1,103	4,945
Warehouses	27	18	42	27	47	84	59	18	19	9	200	19	1	98	6	166	840
IV. MANUFACTURING																	
Metalworkers	10	...	23	14	5	13	1	...	2	1	...	28	1	...	5	78	181
Woodworkers	8	...	11	2	7	29	3	...	12	7	...	158	...	55	6	10	308
Grain mills, elevators	...	...	17	11	12	2	29	30	...	35	...	8	9	4	...	117	274
Food Processing	...	...	3	21	...	44	...	6	...	2	...	37	...	9	...	12	134
Bakeries	7	...	9	4	...	...	6	...	1	...	...	9	...	15	2	22	75
Textile workers	4	...	2	3	...	54	...	...	...	5f	...	2	...	...	4	5	79
Printing	...	...	8	4	8	...	...	5	4	...	...	15	1	...	3	18	66
Laundries	4	...	10	15c	10	...	...	...	3	...	31	37c	...	48	...	36	194
Cleaners, tailors	9	1	18	...	9	...	22f	8f	1	...	30	...	1	59	6f	44	208
Miscellaneous manufacturing	70	220	36	17	21	80	144	29	44	10	648	49	84	66	19	331	1,868
V. MISCELLANEOUS																	
Barns	136	...	236	356	294	177	105	280h	44	353j	472	304h	149	...	27	1,522	4,455
Outbuildings	...	76	125	...	80	...	493	136	126	...	622	...	20	539	28	359	2,604
Lumber and coal yards	8	...	6	6	66	37	12	6	4	3	38	...	6	17	16	20	245
Piers, including shipyards	1	...	...	3	...	...	...	...	...	...	...	...	...	1	...	...	5
Railroad property, inc. rolling stock	...	...	26	22	1	29	17	13	3	...	...	...	4	...	3	333	451
Bulk oil storage, refineries	...	...	3	7	10	50	...	3	...	7	...	...	...	6	...	...	86
Garages	136	11	41	22	98d	23	27d	33	13	32	834d	37	6d	42	29	416	1,800
Filling stations	8	2	26	28	...	...	...	...	5	...	...	22	...	57	13	75	236
Power plants, pump houses	1	...	13	9	8	...	12	3	3	2	...	24	5	...	2	60	142
Creameries and dairies	...	...	5	5	7	...	5	1	3	...	...	3	...	...	...	74	103
Miscellaneous structures	7	278	563	44	4	126	52	18	23	3	1,515	20	4	308	13	487	3,465
VI. OTHER THAN BUILDING FIRES																	
Aircraft	...	...	2	...	...	...	...	...	...	...	...	...	...	...	...	...	2
Motor vehicles	122	325	596	436	353	482	117	193	...	...	2,819	570	126	...	56	1,591	7,786
Forest fires	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Rubbish, grass, brush	...	1,106	44	...	...	...	...	134	...	...	...	...	135	...	...	...	1,419
Miscellaneous	220	573	250	1	169	...	36	106	1	...	126	2	53	2	21	4,230	5,790
Totals	2,011	3,736	4,487	2,955	6,608	5,829	2,946	1,805	1,334	1,430	15,861	13,986	1,221	7,758	1,084	38,600	111,651

1 Fiscal year ended June 30, 1954. 5 Includes losses in towns and cities only. c. Includes dry cleaning. f. Includes laundries. j. Includes farm property, livestock.

Miscellaneous	220	573	250	1	109	...	...	...	...	...	...	...	...	...	...	...	...
Totals	2,011	3,736	4,487	2,955	6,608	5,829	2,946	1,805	1,334	1,430	15,861	13,986	1,221	7,758	1,084	38,600	111,651

1 Fiscal year ended June 30, 1954
2 Insured losses only.
3 Fiscal year ended June 30, 1953.
4 No losses less than $50.
5 Includes losses in towns and cities only.
a. Includes fraternity and sorority houses.
b. Includes clubs.
c. Includes dry cleaning.
d. Includes filling stations.
e. Includes boarding and rooming houses.
f. Includes laundries.
g. Includes apartments.
h. Includes outbuildings.
i. Includes public buildings and jails.
j. Includes farm property, livestock, crops, hay.
k. Includes offices.
l. Includes restaurants.

TABLE II. Fire Losses by Occupancies in Fourteen States — 1953

Occupancies	Conn.[1]	Iowa	Kansas	Kentucky[2]	Louisiana	Minn.	Nebraska	N.D.[2,3]	Ohio	Oregon[4]	S.D.[3]	Texas[2,5]	W.Va.[4]	Wisconsin	Totals
I. Public Buildings															
Government buildings	$650	$60,849	$2,700	$199,930	.....	$1,439	$28,450	$82,445	.....	$4,020	$7,085	.....	.....	$3,665	$391,233
Hospitals, institutions	.....	25,440	1,372	14,530	$124,507	31,685	435	42,435i	$22,570	.....	335	$29,281	$350	20,297	313,237
Schools and colleges	10,325	460,070	320,822	927,417	396,890	210,890	310,719	8,768	178,184	177,420	8,603	568,038	240,309	747,625	4,565,880
Churches	63,613	60,903	98,930	76,960	89,650	439,350	38,791	33,061	508,820	56,478	40,354	493,024	104,550	336,467	2,440,951
Theatres, including motion pictures	12,427	74,450	12,985	116,761	291,037	6,910	32,119	56,529	7,640	26,397	74,070	134,955	.....	17,055	863,815
Amusement, halls	90,472	129,106	86,240	.....	.....	68,510	234,918	.....	667,500	.....	.....	247,982	.....	134,489	1,659,217
II. Residential															
Hotels	23,335	360,163	20,735b	.....	499,733	354,506	16,015	176,382	80,780	238,774e	77,681l	326,670	92,990	212,717	2,480,481
Boarding and rooming houses	41,276	21,044a	14,042a	67,816	.....	.....	81,120g	.....	.....	.....	.....	102,090	.....	26,658	354,046
Apartments	359,492	83,438	69,437	.....	.....	285,639e	.....	.....	1,201,946e	.....	5,101	1,094,180	30,685	106,134	3,206,052
Dwellings	1,692,181	2,415,785	1,067,036	6,453,932	3,331,508	2,102,459	1,051,407	296,993g	6,401,955	4,791,524g	478,929	5,656,934	2,212,490	5,687,940	43,641,073
III. Mercantile															
Offices, banks	35,842	155,032	30,578	136,162	.....	600,715	36,138	.....	371,564	.....	97,134	997,423	377,400	294,746	3,102,734
Restaurants, taverns	292,869	360,135	109,924	289,433	.....	465,528	41,670	.....	.....	147,262	26,323	687,402	137,753	1,055,327	3,613,626
Miscellaneous mercantiles	962,281	1,880,730	1,459,080	3,114,650	1,041,248	2,004,460	566,850	274,298	2,357,067	1,429,131k	758,846	3,204,497	673,886	2,018,492	21,745,516
Warehouses	176,541	161,125	630,831	829,662	463,623	133,679	128,889	149,934	2,207,403	11,052	1,500	1,350,757	54,450	658,109	6,955,155
IV. Manufacturing															
Metalworkers	17,650	25,468	70,386	21,847	77,359	2,500	.....	3,244	.....	104,180	2,878	.....	86,500	119,950	532,062
Woodworkers	54,720	25,773	400	1,076,969	457,125	45,525	.....	5,757	.....	2,360,498	.....	459,431	214,800	4,853	4,705,851
Grain mills, elevators	.....	358,456	322,390	228,831	453,010	537,918	542,767	606,294	.....	235,733	331,589	165,653	.....	194,137	3,976,778
Food Processing	.....	44,650	18,100	.....	224,131	.....	6,045	117,039	.....	59,193	.....	159,755	.....	1,712	640,625
Bakeries	11,345	226,839	10,075	.....	.....	11,995	.....	.....	.....	21,807	.....	30,929	1,859	6,049	320,898
Textile workers	3,700	6,834	26,667	.....	77,460	.....	.....	33,941f	.....	248	.....	.....	7,000	9,673	165,523
Printing	.....	62,272	18,555	11,417	.....	.....	99,067	.....	.....	35,444	295	.....	122,000	3,108	352,158
Laundries	1,500	21,333	25,625c	8,917	.....	.....	.....	.....	27,125	92,536c	.....	87,225	.....	33,130	297,391
Cleaners, tailors	14,689	32,698	.....	5,748	.....	31,033f	4,407f	.....	82,340	.....	100	165,308	30,004f	90,341	456,668
Miscellaneous manufacturing	551,774	185,372	50,301	117,726	149,813	1,839,295	173,758	33,691	4,314,181	140,867	193,250	1,290,113	249,613	2,442,560	11,732,314
V. Miscellaneous															
Barns	584,356	1,443,975	1,413,481	610,824	360,465	697,126	721,905h	384,105j	3,275,766	486,874h	339,073	.....	134,315	2,461,390	12,912,755
Outbuildings	.....	123,247	.....	46,927	.....	524,119	89,528	.....	362,350	.....	6,228	722,410	47,856	98,023	2,020,788
Lumber and coal yards	193,918	101,620	808,755	1,023,806	44,679	280,630	26,700	385	3,386,311	.....	23,866	416,245	331,508	39,672	6,678,095
Piers, including shipyards	4,300	.....	200,500	.....	.....	.....	.....	.....	.....	.....	.....	5,000	.....	.....	209,800
Railroad property, inc. rolling stock	.....	47,499	105,548	17,497	150,863	512,640	27,386	.....	.....	.....	1,490	.....	6,000	43,386	912,309
Bulk oil storage, refineries	.....	925	42,450	87,894	277,913	.....	20,200	2,276	.....	.....	.....	325,201	.....	.....	756,659
Garages	404,175	237,729	202,431	348,075d	137,743	76,053d	217,980	71,202	1,367,616d	75,867	104,093d	165,206	87,025	345,225	3,840,120
Filling stations	14,079	6,717	95,504	.....	.....	.....	.....	.....	.....	39,154	.....	78,755	15,843	13,801	263,853
Power plants, pump houses	1,159	25,171	5,160	24,221	.....	20,010	6,050	1,164	.....	21,021	2,950	.....	35,200	116,887	258,995
Creameries and dairies	.....	52,100	55,516	43,997	.....	31,726	1,050	.....	.....	1,793	.....	.....	.....	72,145	258,327
Miscellaneous structures	5,500	325,031	77,768	8,911	340,656	196,397	121,887	136	4,969,954	24,007	1,850	1,986,336	60,546	310,415	8,429,394
VI. Other Than Building Fires															
Aircraft	.....	85,150	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	85,150
Motor vehicles	67,648	126,821	110,855	286,694	145,896	54,663	204,892	.....	963,794	114,823	49,491	.....	122,862	255,667	2,503,906
Forest fires	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Rubbish, grass, brush	.....	11,433	.....	.....	.....	.....	141,151	.....	.....	.....	96,650	.....	.....	.....	249,234
Miscellaneous	944,971	400,063	109	105,028	.....	69,398	162,043	.....	7,610	666	36,168	750	805,611	648,252	3,181,660
Totals	$6,636,788	$10,234,546	$7,585,079	$16,302,384	$9,135,309	$11,636,798	$5,133,137	$2,380,079	$32,762,476	$10,697,269	$2,765,912	$20,931,550	$6,284,305	$18,598,097	$161,083,729

1 Fiscal year ended June 30, 1954.
2 Insured losses only.
3 Fiscal year ended June 30, 1953.
4 Actual losses where claims were made.
5 Includes losses in towns and cities only.
6 No losses less than $50.
a. Includes fraternity and sorority houses.
b. Includes clubs.
c. Includes dry cleaning.
d. Includes filling stations.
e. Includes boarding and rooming houses.
f. Includes laundries.
g. Includes apartments.
h. Includes outbuildings.
i. Includes public buildings and jails.
j. Includes farm property, livestock crops, hay.
k. Includes offices.
l. Includes restaurants.

TABLE III. Number of Fires by Causes in Seventeen States — 1953

Causes	Conn.[1]	Iowa	Kansas	Ky.[2]	La.	Mich.	Nebr.	N.H.	N.C.[3]	N.D.[2,4]	Ohio	Oreg.[2]	R.I.[5,6]	S.D.[4]	Tex.[2,3]	W.Va.[7]	Wisc.	Totals
Chimneys, flues — defective or overheated	69	130	63	468	82	1,478	53	122	...	73	575	678	47	39	103	79	260	4,319
Sparks on roof	...	...	21	34	...	728	...	...	...	5	...	90	...	...	34	...	...	912
Defective or overheated heating and cooking equipment	152	104	...	...	255	2,770	...	53	...	...	...	...	80	46	204	...	1,560	5,224
Oil-fired equipment	...	19	...	...	250	...	...	...	...	...	...	...	...	...	158	...	196	623
Gas-fired equipment	57	300	179	502	64	3,757	180	201	531	109	997	1,809	71	98	188	82	1,544	10,669
Other and unknown	...	...	161	203	...	9,300	131	21	32	19	701	32	52	85	224	14	174	11,149
Rubbish, ignition unknown	3	66	...	...	...	...	16	1	...	...	...	...	...	...	257	34	343	720
Combustibles near heaters	121	630	67	81	315	471	97	9	53	40	830	140	35	104	39	3	964	3,999
Open lights, flames, sparks	8	34	27	77	...	274	13	7	7	18	118	907	1	8	...	3	126	1,628
Hot ashes, coals	389	518	325	834	994	5,571	173	237	296	153	3,265	4,016	64	129	1,590	74	6,370	24,998
Smoking and matches	...	163	...	...	...	...	74	51	...	...	796	...	41	46	306	29	544	2,050
Children and matches	158	294	330	807	802	2,195	213	123	323	146	2,699	1,059	123	138	1,089	131	2,037	12,667
Electrical, fixed services, fires due to misuse or faulty wiring and equipment	70	279	26	57	...	2,319	56	84	...	16	418	1,021	...	47	87	27	1,830	6,337
Electrical, power consuming appliances	53	140	187	203	...	609	117	76	80	134	850	1,866	44	35	510	41	1,636	6,581
Flammable liquids, misuse of including vapor explosions, grease, tar, etc.	22	24	...	...	...	...	4	1	...	...	...	...	2	9	1	14	73	150
Flammable liquid appliances, including lamps, blow torches, salamanders, etc.	...	34	...	...	32	...	31	15	...	...	87	...	...	16	...	11	72	298
Torches, welding and cutting	...	10	47	34	...	457	14	12	...	26	171	...	...	14	557	28	82	1,452
Gas and appliances, including gas explosions	34	120	24	77	31	4,107	71	15	40	18	350	102	13	28	181	14	281	5,506
Spontaneous ignition	27	155	54	708	440	792	80	125	32	133	236	106	5	48	167	21	16,778	19,907
Lightning	2	...	...	...	...	...	...	...	...	...	...	...	...	...	6	2	8	18
Thawing pipes	...	37	7	34	52	...	20	5	28	11	...	122	...	...	76	4	45	441
Sparks from machinery, friction	52	26	17	18	72	823	20	19	25	2	138	44	31	4	139	59	51	1,540
Incendiary, suspicious	486	465	213	36	307	21,519	46	18	26	78	1,607	5	226	110	252	47	1,762	27,203
Miscellaneous	290	674	1,017	1,933	1,671	7,183	331	74	476	348	1,527	1,578	279	121	1,050	266	1,016	19,834
Unknown	13	...	33	227	...	...	9	...	3	31	...	200	...	18	...	2	549	1,085
Explosions, miscellaneous and unclassified	5	265	157	275	462	1,313	56	47	66	70	496	211	15	78	540	99	299	4,454
Exposure																		
Totals	2,011	4,487	2,955	6,608	5,829	65,666	1,805	1,316	2,018	1,430	15,861	13,986	1,129	1,221	7,758	1,084	38,600	173,764

[1] Fiscal year ended June 30, 1954.
[2] Insured losses only.
[3] No losses less than $25.
[4] Fiscal year ended June 30, 1953.
[5] There were an additional 1,161 insured loss fires not reported to the State Fire Marshal.
[6] Fiscal year ended Sept. 30, 1953.
[7] No losses less than $50.
[8] Includes losses in towns and cities only.

TABLE IV. Fire Losses by Causes in Fourteen States — 1953

Causes	Conn.[1]	Iowa	Kansas	Kentucky[2]	Louisiana	Nebraska	North Carolina[3]	North Dakota[3,4]	Ohio	Oregon[5]	South Dakota[4]	Texas[3,6]	West Virginia[7]	Wisconsin	Totals
Chimneys, flues — defective or overheated	$68,797	$169,417	$49,857	$831,139	$96,641	$122,215	.....	$13,282	$753,968	$357,690	$37,682	$133,769	$230,658	$323,157	$3,188,272
Sparks on roof	.....	.....	22,768	78,823	.....	.....	.....	2,671	.....	45,178	.....	7,092	.....	.....	156,532
Defective or overheated heating and cooking equipment:															
Oil-fired equipment	430,240	142,737	.....	.....	300,353	.....	.....	.....	.....	.....	80,224	248,166	.....	599,043	1,800,763
Gas-fired equipment	.....	22,480	.....	.....	256,120	.....	.....	.....	.....	.....	.....	394,200	.....	119,299	792,099
Other and unknown	263,548	471,340	274,060	1,262,823	73,257	293,499	716,940	304,471	1,972,609	860,158	126,258	366,131	402,220	936,758	8,324,072
Rubbish, ignition unknown	.....	.....	61,011	153,957	.....	124,104	26,738	3,064	677,361	25,145	55,821	309,488	42,065	96,167	1,574,921
Combustibles near heaters	8,500	22,631	.....	.....	.....	10,212	.....	.....	.....	.....	.....	221,057	76,008	30,345	368,753
Open lights, flames, sparks	123,249	483,715	80,396	130,014	355,607	110,923	109,618	19,873	1,049,808	17,962	93,850	513,402	800	478,784	3,568,001
Hot ashes, coals	5,978	12,862	13,037	121,437	.....	7,670	24,625	9,166	127,572	160,794	846	.....	8,300	43,332	535,619
Smoking and matches	657,396	332,620	94,630	835,691	463,708	280,900	523,727	48,250	1,995,193	853,322	49,892	1,942,302	262,314	1,485,140	9,825,085
Children and matches	.....	266,088	.....	.....	.....	62,197	.....	.....	605,204	.....	21,420	234,543	26,964	316,970	1,533,386
Electrical, fixed services, fires due to misuse, or faulty wiring and equipment	485,794	1,119,334	311,352	2,272,284	839,932	687,362	526,771	390,518	3,348,235	1,407,303	379,000	4,092,002	781,029	4,940,383	21,581,299
Electrical, power consuming appliances	130,129	240,892	30,381	32,804	.....	114,613	.....	18,839	270,031	618,962	42,518	144,626	222,889	894,819	2,761,503
Flammable liquids, misuse of including vapor explosions, grease, tar, etc.	345,639	508,201	189,297	257,366	.....	132,997	58,618	62,073	1,725,070	367,974	51,605	589,675	196,282	432,718	4,917,515
Flammable liquid appliances, including lamps, blow torches, salamanders, etc.	30,457	4,547	.....	.....	.....	137,750	.....	.....	.....	.....	18,541	366	38,037	30,753	260,451
Torches, welding and cutting	.....	56,235	.....	.....	73,947	41,121	.....	.....	403,685	.....	48,152	.....	35,171	46,753	705,064
Gas and appliances, including gas explosions	.....	10,396	96,130	61,139	.....	73,495	.....	118,747	392,911	.....	12,331	865,013	95,340	174,471	1,899,973
Spontaneous ignition	198,698	349,300	88,490	202,867	121,255	285,074	525,260	18,996	1,396,168	238,641	83,254	747,967	156,485	1,058,138	5,470,593
Lightning	87,784	607,437	143,773	467,129	403,286	193,605	75,905	134,236	737,957	46,543	91,101	231,376	56,464	1,990,271	5,266,867
Thawing pipes	3,000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	13,293	4,900	3,243	24,436
Sparks from machinery, friction	.....	49,405	2,135	301,185	88,791	35,361	187,460	63,111	.....	620,965	.....	369,119	41,489	7,878	1,766,899
Incendiary, suspicious	130,289	168,567	48,446	115,574	96,738	47,651	74,316	1,061	473,182	143,341	1,642	698,011	474,050	750,134	3,223,002
Miscellaneous	1,364,607	340,564	226,999	48,379	380,393	129,025	22,633	94,581	1,883,986	1,949	94,370	1,040,082	125,524	724,743	6,477,835
Unknown	2,200,870	4,243,444	5,359,843	7,861,762	4,985,216	2,084,331	9,038,056	970,665	14,094,028	4,525,663	972,093	6,735,695	2,652,136	2,588,841	68,312,643
Explosions, miscellaneous and unclassified	90,613	.....	32,314	371,733	.....	74,616	417,419	31,199	.....	144,406	93,524	.....	7,500	275,801	1,539,125
Exposure	11,200	612,334	460,160	896,278	600,065	84,416	169,025	75,276	855,508	261,273	411,788	1,034,175	347,680	250,156	6,069,334
Totals	$6,636,788	$10,234,546	$7,585,079	$16,302,384	$9,135,309	$5,133,137	$12,497,111	$2,380,079	$32,762,476	$10,697,269	$2,765,912	$20,931,550	$6,284,305	$18,598,097	$161,944,042

[1] Fiscal year ended June 30, 1954
[2] Insured losses only.
[3] No losses less than $25.
[4] Fiscal year ended June 30, 1953.
[5] Actual losses where claims were made.
[6] Includes losses in towns and cities only.
[7] No losses less than $50.

Protection. Motor vehicle data are based on a recent survey of 574 U. S. cities (Fire Record of Cities, April, 1954 Quarterly). The estimate of the number of forest fires was taken from the annual summary of forest fire statistics, compiled by the Forest Service of the U. S. Department of Agriculture.

As will be seen in Table V, the 20 states with a population of 53,273,850 reported a total of 174,649 fires. Experience indicates that this is somewhat under half the actual number of fires in these states. Some states, for example, do not report fires with uninsured losses, others report only fires with losses in excess of $50. To obtain a more accurate estimate of the number of fires in these 20 states, 100 per cent is added. Ma use of this figure and the population r the number of building fires for the tion has been calculated.

To obtain the estimated national loss by occupancy, the population was applied to the loss of the repor states. To account for losses not repo through the usual channels, 33 1/3 cent was added as in the previous y Further adjustment was necessary i few instances because of unusually l property damage in individual fires.

The procedure for determining number of fires and amounts of loss tributed to various causes (Table V was similar to that used to estimate o pancy experience.

Table V. Fires per 1000 Population and Fire Loss per Person fo Twenty States, 1953, as Reported by Fire Marshals

State	Population 1950 Census	No. of Fires	Fires per 1000 Pop.	Fire Loss	Fire per P
Connecticut[1]	1,995,263	2,811	1.41	$ 6,636,788	$3.
Delaware	318,085	3,736	11.72	1,846,728	5.
Iowa	2,612,598	4,487	1.72	10,234,546	3.
Kansas	1,894,390	2,955	1.56	7,585,079	4.
Kentucky[2]	2,944,806	6,608	2.24	16,302,384	5.
Louisiana	2,667,022	5,829	2.18	9,135,309	3.
Maine[2]	913,774	....	....	1,201,808	1.
Michigan	6,308,794	65,666	10.40	78,126,592*a*	12.
Minnesota	2,982,483	2,946	0.98	11,636,798	3.
Nebraska	1,318,079	1,805	1.37	5,133,137	3.
New Hampshire	592,880	1,316	2.22	3,714,971	6.
North Carolina[3]	4,061,929	2,018	0.50	12,507,900	3.
North Dakota[2,4]	619,636	1,430	2.33	2,380,079	3.
Ohio	7,946,627	15,861	1.99	32,762,476	4.
Oregon[2]	1,521,341	13,986	9.18	10,697,269	7.
Rhode Island[5]	791,896	2,290	2.89	.....	..
South Dakota[4]	652,740	1,221	1.87	2,765,912	4.
Texas[2]	7,711,194	....	....	38,021,655	4.
West Virginia[6]	1,999,097	1,084	0.54	6,284,305	3.
Wisconsin	3,421,316	38,600	10.51	18,598,097	5.
TOTALS	53,273,850	174,649	3.92	$275,571,833	5.

a. Includes one fire with estimated $45,000,000 loss.

[1] Fiscal year ended June 30, 1954.

[2] Insured losses only. No losses less than $25.

[4] Fiscal year ended June 30, 1953.

[5] Fiscal year ended Sept. 30, 1953.

[6] No losses less than $50.

Table VI. Estimated Distribution of U.S. Fire Losses by Occupancies, 1953

These estimated figures are intended to show the relative order of magnitude of fire losses by occupancies, and while they are reasonable approximations based on the experience in typical states, they should not be taken as exact records for each class. As explained in the text, 100 per cent has been added in estimating the number of fires, and 33⅓ per cent has been added to the losses to cover unreported losses.

	No. of Fires		Losses	
I. Public Buildings				
Government buildings	1,200		$3,930,000	
Hospitals, institutions	1,600		1,790,000	
Schools and colleges	4,200		22,000,000	
Churches	3,300		12,400,000	
Theatres, including motion pictures	1,500		4,490,000	
Amusement, halls	3,200	15,000	10,150,000	$54,760,000
II. Residential				
Hotels	16,100		8,800,000	
Boarding and rooming houses	9,000		7,500,000	
Apartments	35,700		15,300,000	
Dwellings	420,000	480,800	218,000,000	249,600,000
III. Mercantile				
Offices, banks	9,600		13,240,000	
Restaurants, taverns	17,700		23,500,000	
Miscellaneous mercantiles	38,300		105,000,000	
Warehouses	6,700	72,300	39,600,000	181,340,000
IV. Manufacturing				
Metalworkers	2,400		73,885,000*	
Woodworkers	3,200		21,400,000	
Grain mills, elevators	3,000		26,800,000	
Food Processing	1,900		7,000,000	
Bakeries	1,000		2,650,000	
Textile workers	5,500		6,940,000	
Printing	1,300		2,320,000	
Laundries	2,100		2,100,000	
Cleaners, tailors	2,000		2,780,000	
Miscellaneous manufacturing	14,500	36,900	70,500,000	216,375,000
V. Miscellaneous				
Barns	30,000		56,000,000	
Outbuildings	26,000		9,000,000	
Lumber and coal yards	2,000		11,500,000	
Piers, including shipyards	1,900		10,800,000	
Railroad property, inc. rolling stock	5,800		11,845,000	
Bulk oil storage, refineries	1,400		13,980,000	
Garages	20,000		25,840,000	
Filling stations	3,600		3,000,000	
Power plants, pump houses	2,100		4,600,000	
Creameries and dairies	1,800		3,780,000	
Miscellaneous structures	27,400	122,000	36,700,000	187,045,000
Total (Building Fires)		727,000		$889,120,000
VI. Other Than Building Fires				
Aircraft	250		55,000,000	
Motor vehicles	163,000		12,300,000	
Forest fires	154,150		53,500,000	
Rubbish, grass, brush	800,000		.....	
Miscellaneous	55,000	1,172,400	11,800,000	132,600,000
Grand Total		1,899,400		$1,021,720,000

*Includes one metalworking plant fire causing $45,000,000 loss.

Table VII. Estimated U. S. Building Fire Losses by Causes, 1953

These estimated figures are intended to show the relative order of magnitude of fire losses by cau and while they are reasonable approximations based on the experience in typical states, they should be taken as exact records for each class.

	No. of Fires	Loss
Chimneys, flues — defective or overheated	30,000	$22,000
Sparks on roof	13,400	9,600
Defective or overheated heating and cooking equipment —		
Oil-fired equipment	38,000	30,900
Gas-fired equipment	5,600	6,100
Other and unknown	41,000	38,500
Rubbish, ignition unknown	54,500	12,000
Combustibles near heaters	9,000	8,270
Open lights, flames, sparks	25,500	18,000
Hot ashes, coals	12,800	10,700
Smoking and matches	119,000	65,000
Children and matches	25,000	12,800
Electrical, fixed services, fires due to misuse, faulty wiring, equipment	57,000	80,400
Electrical, power consuming appliances	31,400	16,800
Flammable liquids, misuse of including vapor explosions, grease, tar, etc.	35,500	36,600
Flammable liquid appliances, inc'l. lamps, blow torches, salamanders, etc.	4,900	2,740
Torches, welding and cutting	4,500	52,250,(
Gas and appliances, including gas explosions	9,500	13,000
Spontaneous ignition	23,000	37,610
Lightning	40,000	36,620
Thawing pipes	2,300	2,780
Sparks from machinery, friction	2,900	3,700
Incendiary, suspicious	7,500	21,600
Miscellaneous	34,500	18,550
Unknown	72,000	278,600
Explosions, miscellaneous and unclassified	10,200	23,400
Exposure	18,000	30,600
TOTALS	727,000	$889,120

* Includes one cutting torch fire causing $45,000,000 loss.

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protects its property *Automatically*.... gets better FIRE and BURGLARY PROTECTION and

The complete automatic protection supplied our company by ADT Services has proved more effective in safeguarding our property and continuity of operations than former methods. In addition, it has made it possible for us to save $7,000 a year.

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Secretary-Treasurer, Thermac Company

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A NATIONWIDE ORGANIZATION
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Interior Fire Alarm Signaling Systems.

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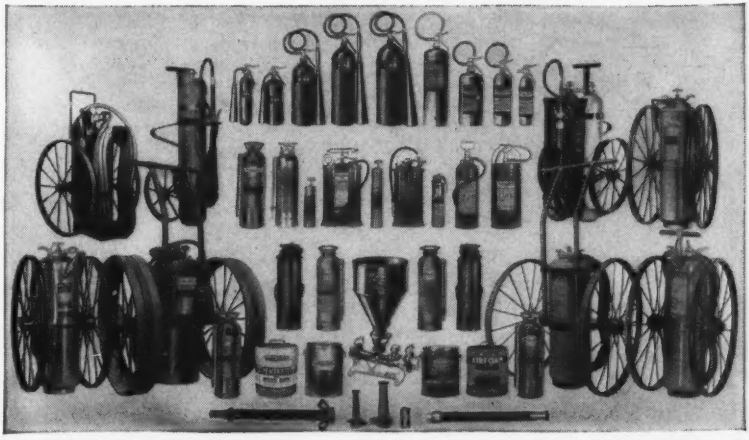
FINEST FIRE-FIGHTING EQUIPMENT



Fire Extinguishers: Foamite, Soda-Acid, Anti-Freeze, all Water Types, Carbon Dioxide, Dry Chemical and Vaporizing Liquid.

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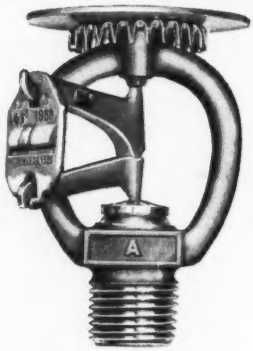
CENTRAL SPRAY SPRINKLERS



Central
Upright Spray
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Combining all the superior features of the Central conventional type of automatic sprinklers (which 34 years of unequalled service have demonstrated) with the Central specially designed spray type of distributors, we present the complete line of Central Spray Sprinklers.

Central Spray Sprinklers are more effective and more efficient than any other type of sprinkler.

CHEAPER COST OF INSTALLATION

Their greater area of distribution and their lesser consumption of water combine to produce earlier extinguishment of fires with less water used, smaller pipe sizes and, in most cases, a lesser number of sprinklers required for the same areas.

Therefore, you save money in first installation cost and your fire damage is lessened if a fire occurs.

In every way, you profit by using the latest developed and the most efficient Central Spray Sprinklers.

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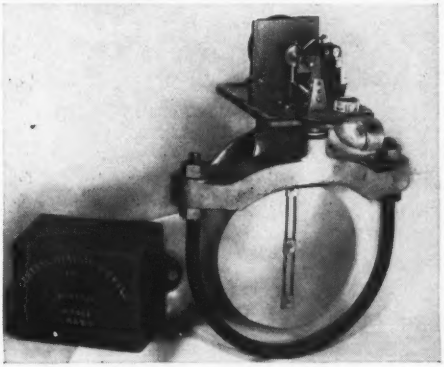
Licensees in principal cities in U. S. of America and Canada and throughout the world.



5-inch size shown above. To install simply drill 2-inch hole in pipe.

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Size is 1⅝" x ⅝"

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- Self restoring and can be heat tested.
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Manufacturers of all kinds of approved devices used in Central Station Systems or Class 'A' or Class 'B' Proprietary Fire Alarm Systems, either automatic or manual.

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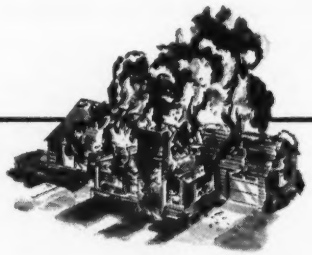
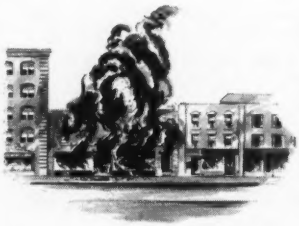


Fire Prevention Benefits Everyone



Every building conserved from destruction by fire benefits everyone in the community. Preventing a fire saves valuable building materials for other use, keeps business in operation and people employed and helps to keep down insurance costs.

Make fire prevention an important part of your activity during the entire year. There is a veritable arsenal of ammunition to draw upon. Motion pictures, posters, prepared talks and booklets are available through our companies, the National Fire Protection Association, the National Board of Fire Underwriters, and the National Association of Insurance Agents.

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Rate Compensation Actuated THERMOSTATS insure positive Fire Detection for alarm or release systems

Fenwal DETECT-A-FIRE units are based on an entirely new principle. The outer shell is the sensing element — reacting to the temperature of the air around it. The contacts function when surrounding air reaches a danger level.

- *Hermetic Sealing* of internal electrical components.
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- *Repeatable*. Unit re-sets itself, nothing to replace.
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SERIES 70 HORIZONTAL MODEL.

For locations where appearance is a factor. Suitable for all commercial, industrial, mercantile and public buildings, institutions and ships, in locations classified as "ordinary" under the National Electric Code.

TYPES 7020 and 7021

Flush Mounting Unit for new construction and concealed wiring. Type 7020, normally closed circuits; Type 7021, normally open circuits. Designed to fit standard 4" junction boxes. For exposed wiring, Types 7020-1 and 7021-1 with surface adapter ring.

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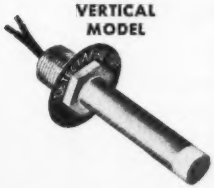

For ordinary and hazardous locations i.e., Class I, Groups C and D; Class II, Groups E, F, and G. Explosion-proof in itself. For hazardous locations, mount to Crouse Hinds CPS 021 Cover or Appleton BFGS Hub Cover for explosion-proof system.

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For concealed and exposed wiring. Type 7120, normally closed circuits. Type 7121, normally open circuits.

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SOMETHING NEW
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Use ROLAGRIP couplings for fast, low cost sprinkler installation

This is a 6" ROLAGRIP coupling for plain end pipe on a sprinkler bulk line in a midwestern aircraft plant. ROLAGRIP couplings and plain end steel pipe were used here because the contractor had to install a permanent, low cost sprinkler system *in a hurry.*

Because the sprinkler system was coupled with ROLAGRIPS, pipe came straight from the mill in economical mill run lots . . . ready to install. It required no special machining, handling or shipping preparation.

Installation time and labor were cut because ROLAGRIPS go on in three easy steps: (1) grease the special synthetic rubber gasket (to prevent pinching) and center it over the pipe ends; (2) lay ROLAGRIP halves over gasket; and (3) insert and tighten two bolts.

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Write for free folder!

Write today for prices and free illustrated folder NCF. (For grooved pipe, investigate approved GRUVAGRIP couplings — sizes ¾" to 14".)

GUSTIN-BACON MANUFACTURING COMPANY

210 West Tenth Street **Kansas City 6, Missouri**

These photos dramatically show protection afforded by Akbar Door in recent fire.

AKBAR

Rolling Fire Doors Made Only By KINNEAR

More Safety Features

Kinnear Akbar Fire Doors provide fast, positive fire protection at doorways and other wall openings.

Doors are automatically pushed downward when fire threatens. A strong spring provides positive action. Downward speed is controlled to insure safety for building occupants . . . and the doors can be opened easily for emergency exits. They automatically close again at once.

Another Akbar safety feature stops the door at sill level, even if the floor is burned away. A special locking device prevents the curtain from coming off the spool.

When not in use, Akbar Doors coil out of the way over the lintel. Approved and labeled by Underwriters' Laboratories, Akbar Doors can save as much as one third of their cost per year in reduced insurance rates!

Each Akbar Door is engineered for the specific opening, insuring the ultimate in closure.

Akbar Fire Doors can be equipped for daily use with motor or manual operation if desired. Where maximum fire protection is not required, non-labeled Kinnear Rolling Doors are recommended.

LARGE SIZES: Kinnear makes doors for firewall openings ranging up to many hundred square feet in area. These large doors are built with the same safety and protective features offered in the labeled doors described above.

Write for details!

KINNEAR ROLLING DOORS

SAVING WAYS in DOORWAYS

THE KINNEAR MANUFACTURING CO.

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1742 Yosemite Ave., San Francisco 24, Cal.
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Underwriters' Laboratories, Inc.

INSPECTED

TYPE EX POWER-OPERATED
INDUSTRIAL TRUCK
FOR HAZARDOUS LOCATION
CLASS 1 GROUP D NO. 101

Designed not only for safety but also economy . . .

Clark's new EXPLOSION-PROOF Carloader

Clark's electric Explosion-Proof Carloader was specifically designed to meet the rigid requirements of Underwriters' Laboratories, Inc. It was the first lift truck to receive Type EX, Class I Group D approval. It is safe for operation in atmospheres containing explosive fumes and vapors, such as gasoline, lacquer, propane.

In addition to *Safety*, the new Explosion-Proof Carloader provides outstanding economy and battery efficiency. It utilizes the same basic control system which enables *all* Clark electrics to outperform other equipment—to work a longer cycle without recharging batteries.

We invite you to compare the new Explosion-Proof Carloader with any comparable truck on the market. Call your local Clark dealer—listed in the Yellow Pages. Or write for details.

CLARK EQUIPMENT

Industrial Truck Division
CLARK EQUIPMENT COMPANY
Battle Creek 190, Mich.

☐ Send details on "EX" Carloader

Name_____

Firm_____

Address_____

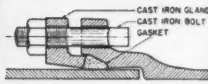
City_____ Zone_____ State_____

MECHANICAL JOINT HYDRANT

M H

EASY to INSTALL

Saves Labor
Saves Time



Made-up Mechanical Joint cut away to show its design.

UL&FM APPROVED & LISTED

The use of mechanical joints for pipe, valves and hydrants is growing rapidly. The reasons are easy assembly, saving in time and labor cost, and flexibility that maintains a tight, leak-proof joint under conditions such as pipe line expansion, contraction or settling.

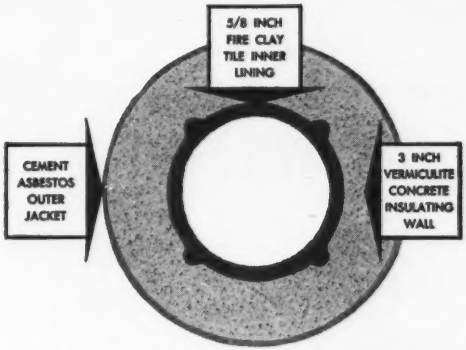
M & H Mechanical Joint hydrant is standard compression type. The main valve opens against the pressure. Hydrant valve will remain closed in case hydrant standpipe is broken off in traffic accident. Other features include low friction loss, revolving head, dry top, easy lubrication. Hydrant shoe has two heavy lugs for use in strapping hydrant to dead-end pipe line.

M & H Hydrants are approved and listed by Underwriters' Laboratories of Chicago and Factory Mutual Laboratories of Boston. Mechanical Joint Ends are made in accordance with A.S.A. standard specification A21.11, 1952, in which a thick gasket of triangular cross section is compressed by a bolted follower ring.

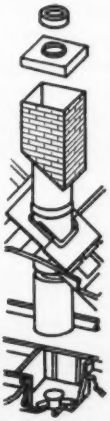
For complete information, write or wire M & H VALVE AND FITTINGS COMPANY, Anniston, Alabama.

M&H PRODUCTS FOR WATER WORKS • FILTER PLANTS INDUSTRY • SEWAGE DISPOSAL AND FIRE PROTECTION

Van-Packer Safety Chimney is genuine masonry construction



Cross-section view shows all masonry construction



Withstands 2100° F.—The Van-Packer Packaged Masonry Safety Chimney is built with a ⅝" fire clay tile liner (the *only* material proven safe by fire safety men thru the years). The liner will withstand temperatures in excess of 2100° F.

Safety of 24" Brick Wall—Van-Packer's 3" insulating concrete wall is equivalent to a 24" brick chimney wall, so safe that wooden rafters can be in direct contact with chimney (Underwriters tested and so listed). Section joints are permanently sealed with acid-proof, leak-proof joint cement.

Approved for All Domestic Fuels—FHA accepted, UL listed, and approved by major codes and U. S. Army Engineers for all domestic fuels.

For further information on the Van-Packer Chimney write for Bulletin No. 41J-AF28

Van-Packer

Packaged Masonry Safety Chimney with "Brick-Panel" Housing

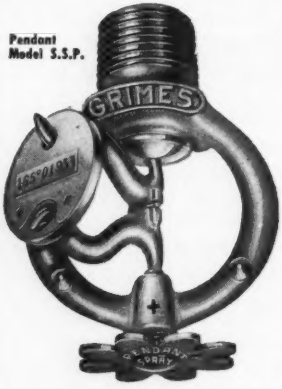
Van-Packer Corporation • Bettendorf, Iowa

GRIMES

Upright
Model S.S.U.

Automatic

SPRAY SPRINKLERS



Pendant
Model S.S.P.

ENGINEERED FOR BETTER FIRE PROTECTION

LOWER INSTALLATION COST
Fewer Sprinklers Needed Per Area

LOWER CEILING TEMPERATURE
More Uniform Lateral Distribution of Water

MINIMIZES FIRE and WATER DAMAGE
Extinguishes Fires Faster With Less Water

INTERCHANGEABLE WITH CONVENTIONAL SPRINKLER HEADS

GRIMES DEVICES are approved by all Insurance Interests

Manufactured and Installed by

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SPRINKLER DIVISION

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from your AIR FOAM System?

This photomicrograph is the revealing secret of **NICEROL** *AIR FOAM'S TRULY AMAZING heat stability*

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NICEROL Air Foam Liquid can be used with all approved types of air foam systems and nozzles.

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Keeps longer in storage—Puts out more Fire Faster Outlasts the Fire

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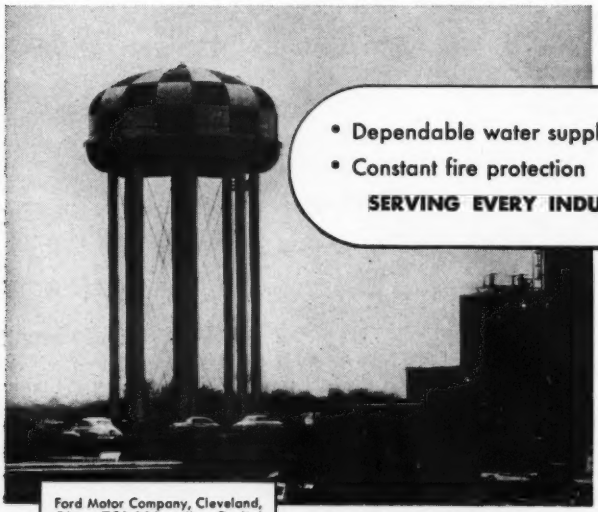

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- Constant fire protection

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Elevated Steel Tanks

These recently-erected tanks, serving the water storage requirements of two new Ford Motor Company plants, typify the hundreds of industrial PDM Elevated Steel Tank installations for companies of every size from coast to coast. Let us consult with you on the type and capacity of tank best meeting the demands of economy, efficiency and safety for your plant.

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DALLAS (1) . . . . 1273 Praetorian Buildin
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(Incorporated)

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Secretary-Treasurer

366 Madison Ave., New York (17) N. Y.
MURRAY HILL 2-2925

If You Are Contemplating Purchase Of Products For The Protection Of Records From Fire Or Theft

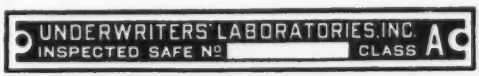
BEWARE OF UNLABELED PRODUCTS!!!

Products of very doubtful fire or burglary protective qualities are appearing on the market. They are described as "insulated" in what many informed persons believe to be a deliberate effort to imply protection which in reality does not exist.

Their exaggerated claims of protective qualities have no foundation in fact. These products carry no recognized label certification and their protective qualities of even minimum standards cannot be substantiated.

These misrepresentations and misleading claims about "insulated" products—with the resulting danger of a sense of false security on the part of users of these products — are matters of grave concern to the members of the Safe Manufacturers National Association. The members of this Association make approximately 95% of the certified, scientifically tested insulated equipment manufactured in the United States.

When you purchase equipment for the protection of records or other valuables, insist that the products you buy carry either the label of the Safe Manufacturers National Association or that of the Underwriters' Laboratories — or both.



The label of Underwriters' Laboratories certifies tested performance by this testing organization whose findings are generally recognized as the impartial and authoritative criterion of fire safety.

Labels of the Safe Manufacturers National Association (SMNA) represent certification by the manufacturer that his product meets the specified standards of performance under fire conditions.

Don't be misled by the unsubstantiated claims of unscrupulous manufacturers. Both impartial labeling services are available to any manufacturer whose products qualify.

LOOK FOR THE LABEL AND BE SURE YOU ARE SAFE!!!

Members, Safe Manufacturers National Association, Inc.

Diebold, Inc., Canton 2, Ohio
Hall's Safe Co. Inc., Hamilton, Ohio
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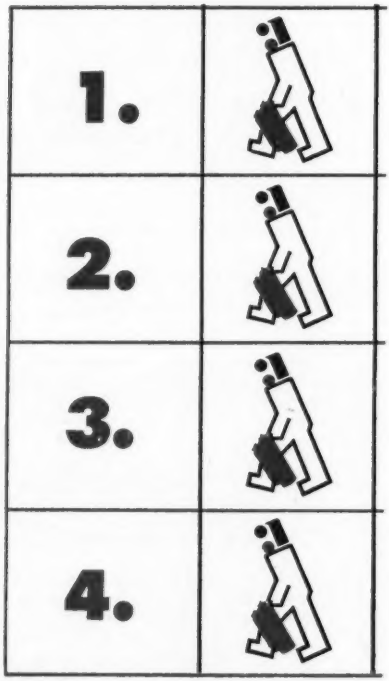
Four reasons fire protection is faster_

Here is the Big Service Plus offered only by Ansul:

A complete fire protection program for your plant and your employees

- Personnel training in your plant by experienced Ansul instructors.
- Customer training school at Ansul plant, Marinette, Wisconsin. Write for schedule and registration information.
- Visual aids for your safety meetings and other training.
- In-plant survey to determine your fire protection needs.



Call the Ansul Man!

Get in touch with your local Ansul man through the "yellow pages" or write ANSUL CHEMICAL COMPANY, Fire Equipment Division, Department F-112, Marinette, Wisconsin.

why Ansul equipment more effective!

WEATHER-TIGHT CONSTRUCTION. Ansul extinguishers are water-tight and corrosion resistant, always ready for action even after extreme weathering and exposure to wide temperature variations.

PATENTED NOZZLE. To ensure full fire coverage, Ansul's patented nozzles deliver the right kind of stream for your fire protection problem (low velocity or high velocity, depending on hazard).

SEALED PRESSURE CARTRIDGE. A positive activating system puts Ansul "Plus Fifty" dry chemical to work immediately—no delay. Cartridge replacement in the field is simple, no tools are necessary.

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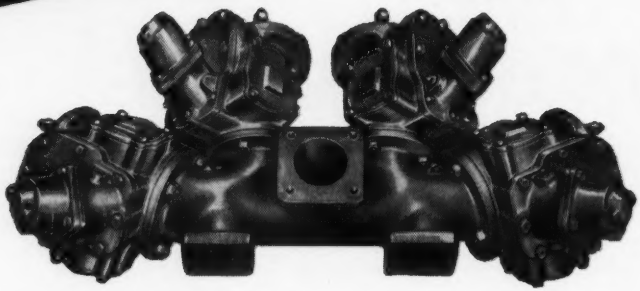
Like PAT and MIKE



The Shand & Jurs HYDRAFOLD valves and INTERNAL SAFETY valves go hand in hand like Pat and Mike. But it's no joke how they provide maximum efficiency in the discharge of truck tank contents The S&J HYDRAFOLD valves enable just one meter to serve several tank compartments through a manifold. These valves and corresponding INTERNAL SAFETY valves are selected and operated simultaneously by the S&J Operator. Both the HYDRAFOLD and INTERNAL SAFETY valves are normally held closed by spring pressure and can be opened only by the time proven, dependable hydraulic pressure system. Tiny fusible plugs which melt at 165° F. are located strategically in the hydraulic lines. Should fire endanger the truck tank or contents the plugs will melt releasing hydraulic pressure and allowing both the HYDRAFOLD and INTERNAL SAFETY valves to close instantly. Designated by S&J as Fig. 13050, these HYDRAFOLDS are available in 3" and 4" sizes. Another model, Fig. 13930 is available in the 2" and 3" sizes.

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The building that died of thirst

This fire would have been quickly controlled and the building saved had it had an automatic Rockwood sprinkler system. Instead, it was unsprinklered. Result: a $1,500,000 property damage, including valuable records that are gone forever, loss of jobs for all employees, loss of customers now forced to seek a new source of supply.

Many buildings face the same peril. Fortunately, this can be remedied easily. What's more, a new type of Rockwood WaterFOG Sprinkler Head now brings amazing Rockwood WaterFOG to conventional sprinkler systems, making them more effective than ever.

The new Head, which covers 30% more area than ordinary heads, is a result of years of research by Rockwood engineers working closely with engineers in the U. S. Navy, municipal fire departments and industry. The Head sprays water into millions of particles which burst into a blanketing mist. This mist cools the temperature, covers nearby flammables and smothers the fire. For complete information, send coupon.

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SPRINKLER COMPANY

ROCKWOOD *Engineers Water.. to Cut Fire Losses*

SEND FOR THIS INFORMATIVE BOOKLET

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Please send me the 12-page illustrated booklet, "15 Types of Fire Protection," giving actual case histories of different types of fire control.

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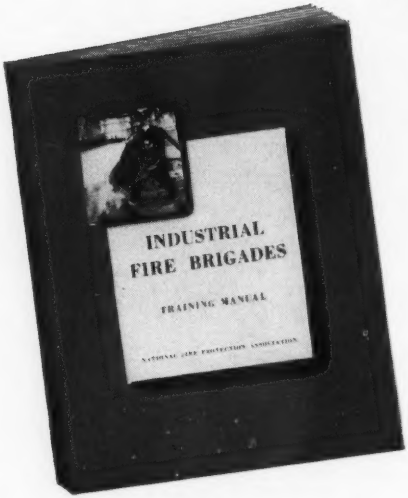
1954 Edition . . . Thousands Sold . . .

INDUSTRIAL FIRE BRIGADES Training Manual



How to Organize and Train a Modern Fire Brigade in Your Plant

160 pages and 385 illustrations

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- Greater Coverage!
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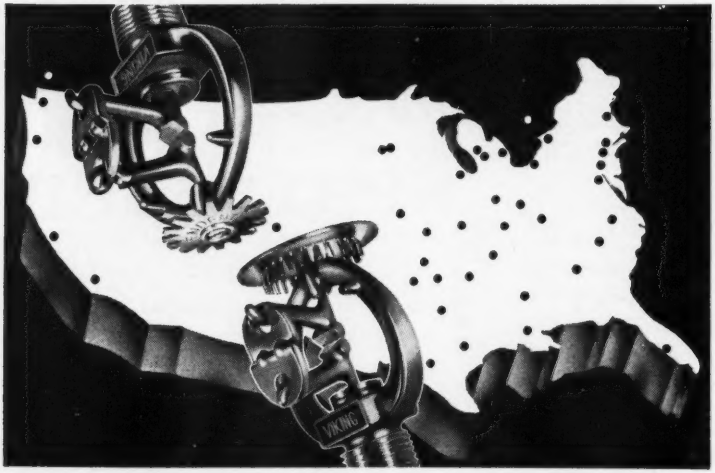
- Better Fire Extinguishment with Less Water!
- Fewer Sprinklers Operating Adjacent to Fire Area!

Incorporating the new principle of water distribution, the Model "C" Spray Sprinkler is another example of Reliable's leadership in new product design. All Reliable Sprinkler Devices are the assurance of the ultimate in fire protection . . . and have been protecting life and property for over 30 years! Reliable Sprinkler Devices are distributed . . . installed and serviced by Reliable's chain of licensed representatives located throughout the United States, Canada and foreign countries. A Reliable representative is as near as your phone. . . . Call him for a system designed to your specific needs!

Constant Fire Protection That's Always "Reliable"!

THE RELIABLE AUTOMATIC SPRINKLER CO. INC.



VIKING SPRINKLER FIRE PROTECTION

for any condition whatever it happens to be!

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SAFER

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THIS NEW TOKHEIM HAND PUMP contributes to safer handling of volatile liquids wherever used. Stops wasteful dripping and slippery floors. Reduces fire hazard and accidents common to other methods of liquid transfer. Approved for handling petroleum liquids—ideal for many others. Available in hose and spout models—for drums, skid tanks and underground installations. Order from your dealer, your oil company or your Tokheim representative. **Write factory for literature.**

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Star Spray Sprinkler!

(MODEL C—UPRIGHT)

With its

Unequalled Performance

Gives You . . . . . .

SUPERIOR PROTECTION — revolutionary in method — for any type of occupancy — no matter how severe the hazard . . . . . with

LESS WATER USED — more effectively and more efficiently — for total extinguishment and cooling. . . . All water discharged goes directly on the fire — not on the ceiling. . . . Ceilings are so cooled that no sprinkler will open unnecessarily. . . . . .

STAR SPRAY SPRINKLERS — the ultimate in modern fire protection — can replace former-type sprinklers without changes in piping. . . . . Available for installation in either **UPRIGHT** or **PENDENT** position.

Approved by Factory Mutual Laboratories
Listed by Underwriters' Laboratories, Inc.

Write for name and address of STAR licensed contractor nearest your location, to:

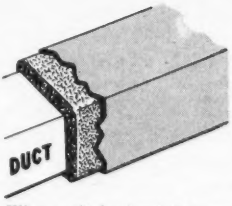
STAR SPRINKLER CORP.

Westmoreland and Collins Sts. — Philadelphia 34, Pa.

Licensees in all Principal Cities of the United States and Canada

FIRE-BAN COATING
INSULATION
FIRE BAN
Permanent • Fire Retardant
SURFACE COATING
For surface application; by brushing, spraying or trowelling, in one coat (1/16" to 1/4" thickness). Applied over cork, cellulose boards or unpainted wood; fiber, foam glass and other types of sheet or block insulations.
Listed by Underwriters' Laboratories, Inc.

When applied to insulation, Fire-Ban provides fire-safety construction. Hard, rigid surface protects insulation against mechanical injury. Permanent smooth, washable surface purest white or choice of colors.



When applied to insulation covering ventilating ducts, Fire-Ban not only provides a fire-retardant surface, but a hard, rigid protection against mechanical damage to the insulation. Surface is smooth and cleanable, decreasing accumulation of combustible dusts.

FIRE-BAN is a 100% inert composition that will not burn . . . prevents ready ignition of combustible materials . . . frequently saves fire rate penalty of combustible building materials. Conforms to "slow-burning" requirements of Federal Specifications SS-A-118a.

FIRE-BAN is economical enough for low cost construction. Weighs only 6½ oz. per sq. ft. when applied 1/16" thick. No reinforcement required . . . no surface scoring needed to provide for expansion.

FIRE-BAN provides a monolithic surface that will not curl, blister, check, craze or peel. Not affected by extreme temperature fluctuations, withstands drops to minus 75° F. The surface is none-dusting and non-toxic; does not become tacky when subjected to frequent washings. Thoroughly "field-tested" for over six years.

FREE SAMPLES

Samples of Fire-Ban applied to wood, fiber or cork board, foam glass, Styrofoam, Rubatex and fiber glass supplied upon request. Please specify.

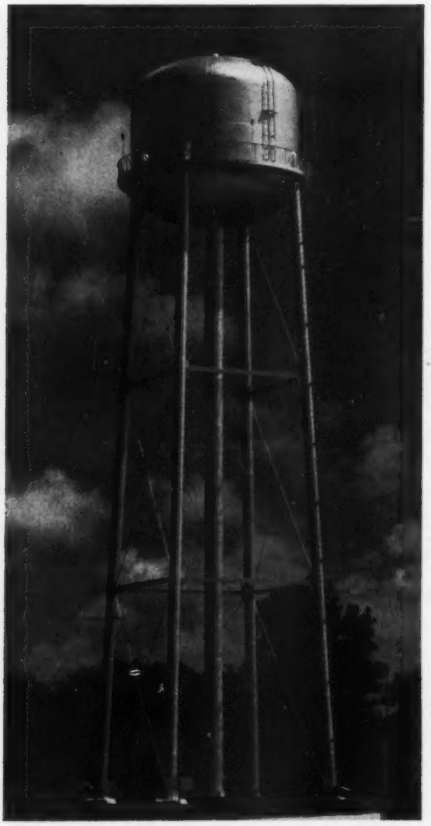
Fire Protection Engineers, Inspectors, Architects, etc., can obtain samples of Fire-Ban with instructions for experimental use . . . no charge or obligation. Write for new Bulletin 54 or outline your problem.

E. H. O'NEILL FLOORS COMPANY

2531 South 50th Ave. **Cicero 50, Illinois**

HORTON ELEVATED TANK

Protects Underwriters' Laboratories Testing Plant



The 100,000-gallon Ellipsoidal elevated bottom tank shown on the left was installed at the Underwriters' Laboratories Testing Plant in Northbrook, Illinois. The tank, 100-ft. to the bottom, is used as the primary water supply for their sprinkler system.

A 6,000-gallon and a 2,000-gallon reservoir interconnected through the pump house to the sprinkler system serve as the secondary water supply.

Underwriters' Laboratories, Inc., established in 1894 as a non-profit organization operates laboratories for the examination and testing of devices, systems, and materials. The Northbrook laboratories consist of four buildings containing a total of 46,000 square feet. Except for the pump house and fire station, the 388 sprinkler heads protect the entire plant.

Elevated tanks are also used as a secondary water supply for automatic sprinkler systems where the public water system cannot deliver a sufficient volume of water at a satisfactory pressure. Horton elevated steel tanks are available in capacities to fit your particular needs.

For additional information or estimates write to our nearest office below.

CHICAGO BRIDGE & IRON COMPANY

ATLANTA	CHICAGO	LOS ANGELES	SALT LAKE CITY
BIRMINGHAM	DETROIT	NEW YORK	SAN FRANCISCO
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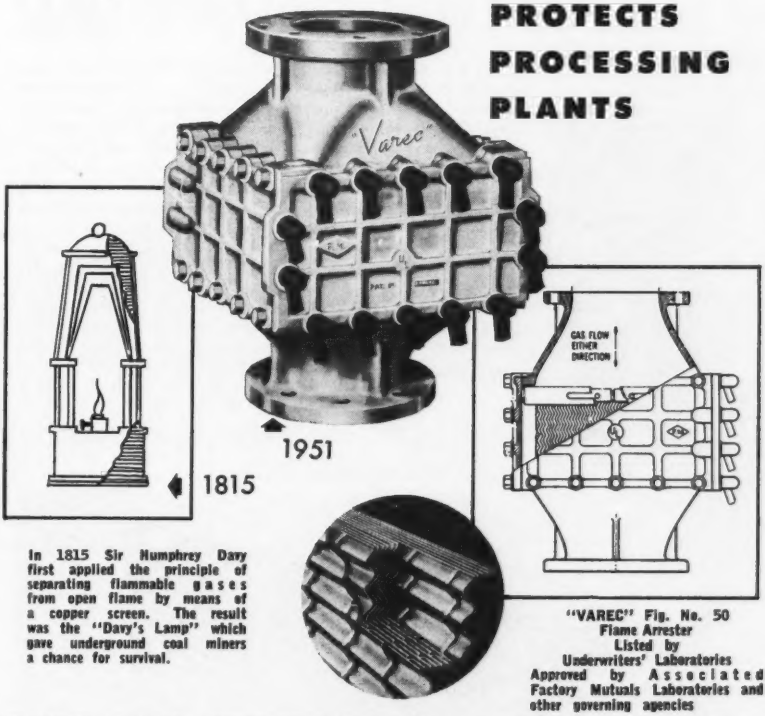
"Davy's Lamp"

PROTECTS PROCESSING PLANTS



In 1815 Sir Humphrey Davy first applied the principle of separating flammable gases from open flame by means of a copper screen. The result was the "Davy's Lamp" which gave underground coal miners a chance for survival.

"VAREC" Fig. No. 50 Flame Arrester Listed by Underwriters' Laboratories Approved by Associated Factory Mutuals Laboratories and other governing agencies

"VAREC" FLAME ARRESTERS utilize this age-old basic principle of heat transfer in protecting plants, equipment and lives against fire and explosion wherever gas or flammable liquids are stored.

They stop burning gas in piping from rapidly propagating thus preventing fire and explosion. Heat of the flame is dissipated through the many surfaces of the multiple corrugated aluminum plates within the unit. Resultant heat loss, plus the tortuous passageways through which the flame would have to pass, stops flame propagation just as the copper screen did in the "Davy's Lamp."

"Varec" Flame Arresters are a low cost investment in the utmost safety for your plants . . . consult your "Varec" representative or write direct.

NF 2

THE VAPOR RECOVERY SYSTEMS COMPANY

COMPTON, CALIFORNIA, U. S. A.

Cable Address: VAREC COMPTON USA (All Codes)

PROVED and APPROVED "Varec"

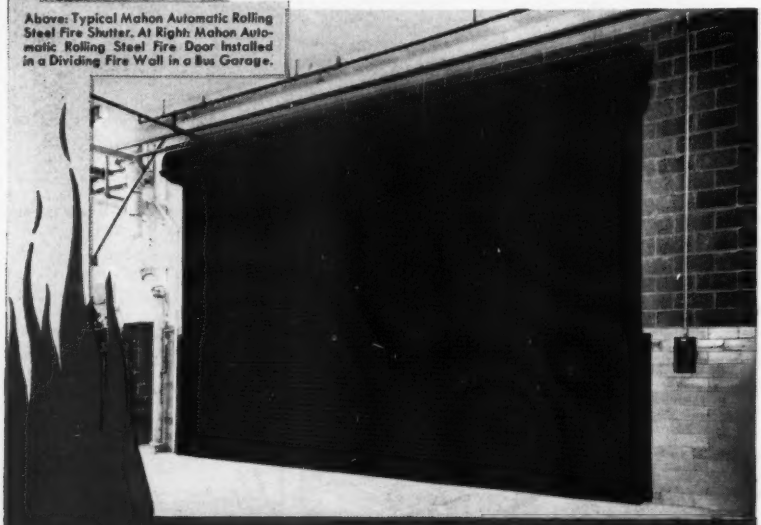
Automatic Rolling Steel
FIRE DOORS *and* WINDOW SHUTTERS
PREVENT SPREAD *of* FIRE!

You need good automatic fire doors in fire walls, corridors, and vertical shafts . . . in some cases automatic rolling steel window shutters are necessary to protect your building and its contents from fires which may originate in nearby buildings. Many, many cases are on file which confirm that timely action of automatic rolling steel fire doors and window shutters have confined a fire to its point of origin and permitted its being extinguished with comparatively small damage. Make a survey of your building now, and don't delay action. You will find a Mahon Automatic Rolling Steel Fire Door or Window Shutter to meet each of your requirements—all bear the Underwriters' Label. These automatic fire doors may be operated manually or mechanically in every day use. If a fire should break out while they are in the open position, the automatic mechanism will close the door, cutting off drafts and preventing the spread of the fire. See Sweet's Files for complete information, or write for Catalog 654.

THE R. C. MAHON COMPANY
Detroit 34, Michigan • Chicago 4, Illinois

Manufacturers of Automatic Rolling Steel Fire Doors and Window Shutters. Also Many Types of Standard General Service Rolling Steel Doors and Grilles, Insulated Metal Walls, and Steel Deck for Roofs, Floors and Partitions.

Above: Typical Mahon Automatic Rolling Steel Fire Shutter. At Right: Mahon Automatic Rolling Steel Fire Door Installed in a Dividing Fire Wall in a Bus Garage.



MAHON ROLLING STEEL FIRE DOORS and WINDOW SHUTTERS

TWO OF THE GREATEST NAMES IN FIRE PROTECTION HAVE JOINED FORCES

PYRENE and C-O-TWO, world-renowned manufacturers of approved fire protection equipment, are now unified under the same management to give you the finest and most complete line on the market today . . .

- ★ **built-in fire detecting systems that quickly respond to smoke, heat or flame . . .**
- ★ **all types of portable fire extinguishers and built-in fire extinguishing systems that kill fire fast . . .**
- ★ **plus an expert fire protection engineering service that gives you unbiased advice on what is best for your particular fire hazards.**

Don't take unnecessary chances . . . the combined fire protection experience of PYRENE and C-O-TWO over the years is at your disposal without obligation. Get complete facts today!

Pyrene **PYRENE — C-O-TWO** C-O-TWO

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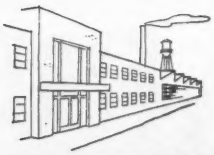
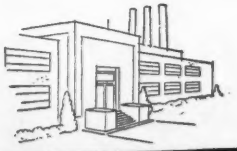
Sales and Service in the Principal Cities of United States and Canada

COMPLETE FIRE PROTECTION

portable fire extinguishers . . . built-in fire detecting and fire extinguishing systems

CARBON DIOXIDE • DRY CHEMICAL • VAPORIZING LIQUID • SODA-ACID • WATER • CHEMICAL FOAM • AIR FOAM





Von Duprin fire and panic exit devices

"THE SAFE WAY OUT!"

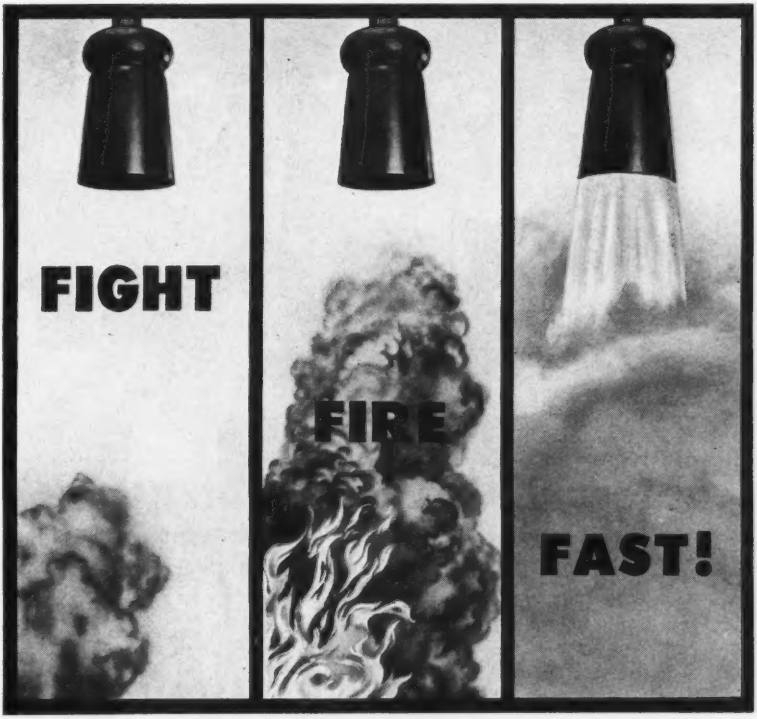
In buildings of all types all over the nation . . . wherever "safe exit" is a factor . . . Von Duprin devices are on duty.

Through proved performance and continuous improvement—ever since Von Duprin marketed the original exit device in 1908—these products have earned the confidence and trust of all safety-minded people.

For expert help in selecting the type of device best suited to your needs, call on your Von Duprin "Exit Specialist." For his name, write Von Duprin, or contact the contract hardware distributor in your own community.

Von Duprin PANIC DEVICES ASSURE SAFE EXIT ®

VONNEGUT HARDWARE CO. • VON DUPRIN DIVISION
INDIANAPOLIS 9, INDIANA



WITH A KIDDE CO_2 SYSTEM!

Let fire get a foothold, and a going concern is *gone*. Don't risk it – see that a Kidde Automatic CO_2 Fire Extinguishing System is on the job, and fire won't stand a chance.

A Kidde System goes into action at the first sign of fire – releases clouds of CO_2 over the blaze, smothers fire almost as soon as it starts. What's more, CO_2 leaves no mess to clean up *after* the fire.

Make sure that flammable liquids, dip tanks, spray booths are protected by a Kidde System.

Let Kidde guard record vaults, machinery and electrical equipment.

And for on-the-spot protection, nothing beats a Kidde portable. When fire strikes, anyone nearby just aims the horn, pulls the trigger, and swoosh! No more fire. Find out more about complete Kidde protection. Write today.

Walter Kidde & Company, Inc.
1051 Main St., Belleville 9, N. J.

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The words 'Kidde', 'Lux', 'Lux-O-Matic', 'Fyre-Freez' and the Kidde seal are trademarks of Walter Kidde & Company, Inc.

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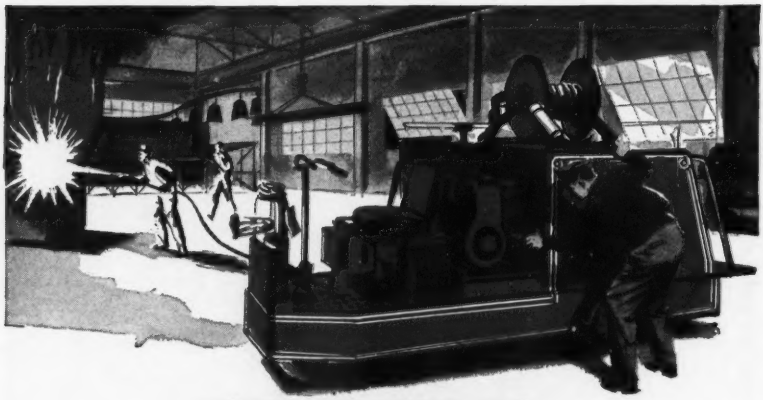


STOP FIRES
before they become Disasters

WITH THE NEW
KALAMAZOO
Fire Fighter

Your own IN-PLANT FIRE DEPARTMENT will snuff out dangerous blazes in seconds.

15 MPH—3-wheel maneuverability—equipped for any type of plant.

Every day, fire disasters cripple firms through lost production and lost markets—the costly result of inadequate or malfunctioning equipment.

That's why the new mobile Kalamazoo Fire Fighter is the perfect addition to any plant or warehouse. It maneuvers through narrow aisles and standard doorways—and turns "on a dime." It comes equipped with a complete fog system, a 210-gallon water tank, 100-ft. hose, or any chemical extinguishers required for your particular plant—whether you produce paint, plastics, etc.

Don't delay—a Fire Fighter will be invaluable insurance against a fire disaster. Write Dept. QF-7.

K KALAMAZOO
MANUFACTURING COMPANY
1827 Reed St. Kalamazoo, Mich., U. S. A.

FOR OVER 71 YEARS SERVING INDUSTRY AND RAILROADS ALL OVER THE WORLD

REMEMBER...

...there's more to fire protection than just the devices

Many firms manufacture excellent protective devices. In fact, those offered by Blaw-Knox are among the finest. But, more important is the way in which these devices are put together into a fire protection system. Without a system engineered and installed to guard against your particular hazard, the most effective devices are worthless!

Fire is unpredictable. It strikes quickly and when least expected. Be prepared to strike back — with a Blaw-Knox Automatic Fire Protection System.

Blaw-Knox will engineer and install the type of system that will provide you with a maximum of protection, at a minimum of cost. No cash outlay is required, and the system will pay for itself in reduced insurance premiums within a few years. Let a Blaw-Knox Fire Protection Engineer study your needs and submit an estimate . . . absolutely without obligation.

BLAW-KNOX FIRE PROTECTION SYSTEMS CARRY APPROVALS OF ALL UNDERWRITERS.
Deluge Systems — Wet Pipe Systems — Dry Pipe Systems — Water Spray and Fog Systems — Rate-of-Rise Sprinkler Systems — Foam and Carbon Dioxide Extinguisher Systems.
You'll be interested in the new Blaw-Knox booklet, *"Fire Can Destroy Your Business."* There's no charge. Write for it.

"Little Joey Sprinkler"

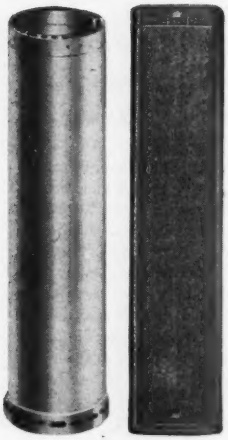
BLAW-KNOX COMPANY
Automatic Sprinkler Department • Pittsburgh 33, Penna.

BLAW-KNOX *always on the job*

FOR GAS APPLIANCE VENTING

There's no doubt about

METALBESTOS



QC WV

METALBESTOS

for every Type B venting need

Approved by Underwriters' Laboratories. Correctly designed for use with all approved gas appliances requiring Type B vents. (Not for use with oil-burning appliances or gas-fired incinerators.)

QC METALBESTOS
Round Vent—for standard venting applications where space is not restricted.

WV METALBESTOS
Oval Vent—specially designed for in-the-wall venting.

IT'S SAFE

. . . . . because Metalbestos provides an inner "hot stack" for complete removal of *all* vent gases and a cooler, safer outer pipe to protect adjacent surfaces from overheating. Metalbestos was first to introduce the double-wall, insulated vent pipe — now accepted as the standard for proper venting.

IT'S DEPENDABLE

. . . . . because Metalbestos vents are designed to last the lifetime of the house. All-metal construction will not crack or break . . . precision made couplers stay gastight, won't pull apart. Assembled vent is strong and rigid and offers maximum protection against corrosion or accidental damage.

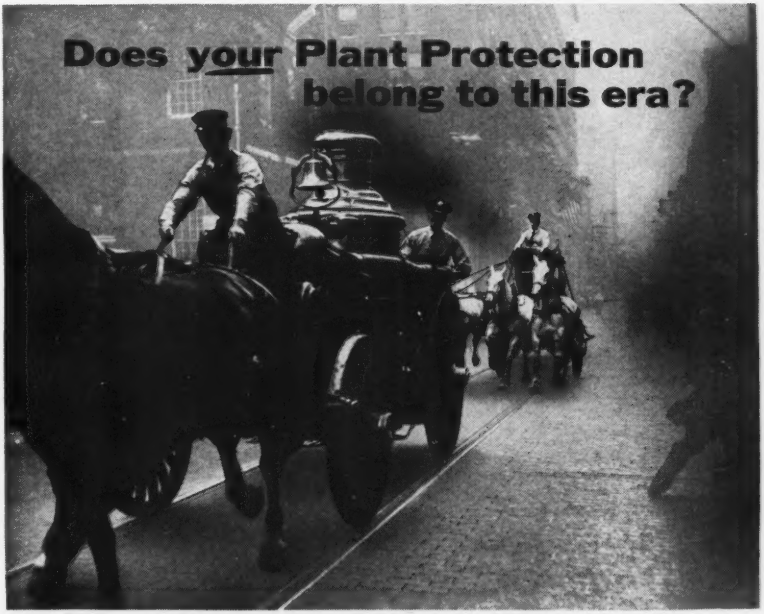
IT'S CORRECT

. . . . . because Metalbestos design is based on venting principles tested and proved by the most extensive venting research ever conducted. You can expect the *best* from Metalbestos — leader in gas venting.

TYPE B-W INSTALLATION KIT for safe, approved wall heater venting.

Simplifies venting of recessed wall heaters — fits inside 2 x 4 walls without furring out. Contains all fittings and directions needed to make safe, officially correct installation. Designed for use with WV Metalbestos pipe. Approved by Underwriters' Laboratories, Inc.

METALBESTOS DIVISION
WILLIAM WALLACE COMPANY • BELMONT, CALIF.



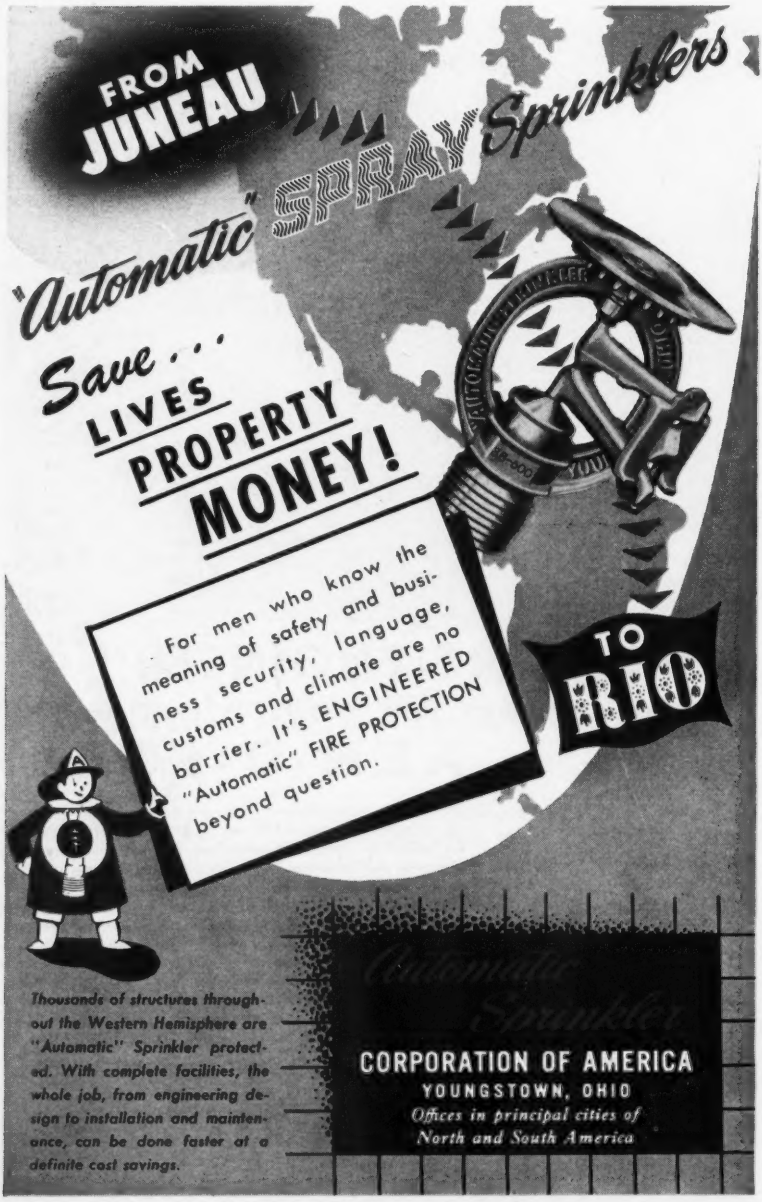
Let Us "FIRE-ENGINEER"
a system for your plant with
AER-O-FOAM

The science of fire-engineering has come a long way since the era of the horse-drawn fire engine. Now you can protect your flammable liquid fire hazards by calling in National Foam engineers, who survey your plant and plan a modern fire-engineered system for your particular needs. They check locations, processes, flash points, existing system, water supply, and other factors. They recommend a basic AER-O-FOAM System with manual or automatic control, stationary or mobile operation, and all the proper equipment . . foam chambers, overhead units, dip-tank systems, nozzles, extinguishers. After installation, National Foam furnishes a complete operating manual.

National Foam's modern fire-engineered service offers the best in system design, equipment, and instant, positive, fire-tested AER-O-FOAM. Call in National today to discuss your flammable liquid fire problem.

Write for new, free booklet, "Foam Fire Protection"

NATIONAL
FOAM SYSTEM INCORPORATED
Headquarters for Foam Fire Protection — WEST CHESTER, PA.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JUNEAU
"Automatic" SPRAY Sprinklers
Save...
LIVES
PROPERTY
MONEY!
For men who know the meaning of safety and business security, language, customs and climate are no barrier. It's ENGINEERED "Automatic" FIRE PROTECTION beyond question.
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Thousands of structures throughout the Western Hemisphere are "Automatic" Sprinkler protected. With complete facilities, the whole job, from engineering design to installation and maintenance, can be done faster at a definite cost savings.
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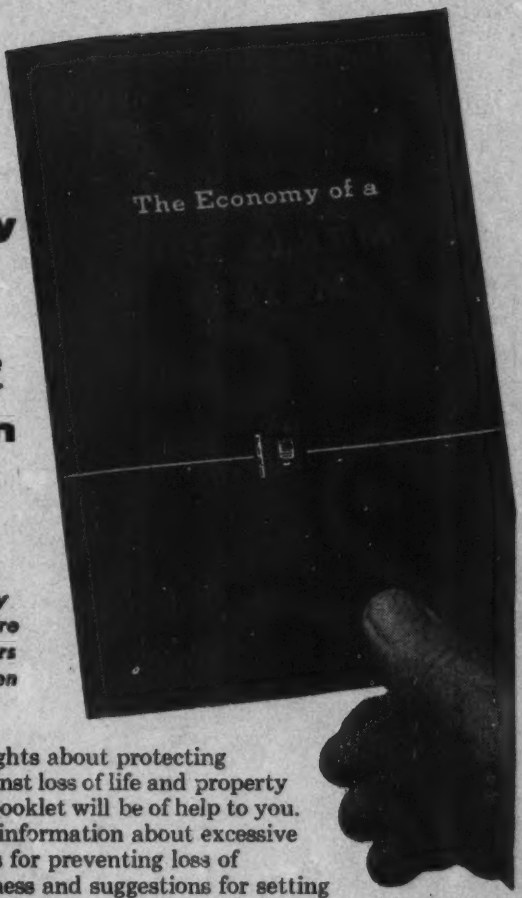
Offices in principal cities of
North and South America

How necessary is an adequate Fire Alarm System?



Answers Questions that may be asked by Average Citizens • Store Owners • Manufacturers Bankers • Insurance Men City Officials

Whatever your thoughts about protecting your community against loss of life and property by fire, this 24-page booklet will be of help to you.

In it you will find information about excessive fire damage, methods for preventing loss of payrolls, loss of business and suggestions for setting up an adequate fire alarm system. Communities from 10,000 population and up have received savings in insurance premiums, as well as reductions in property loss, as a result of the information in this booklet. Send for your copy today, at no obligation, of course.

GAMEWELL®

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NEWTON UPPER FALLS 64, MASS.

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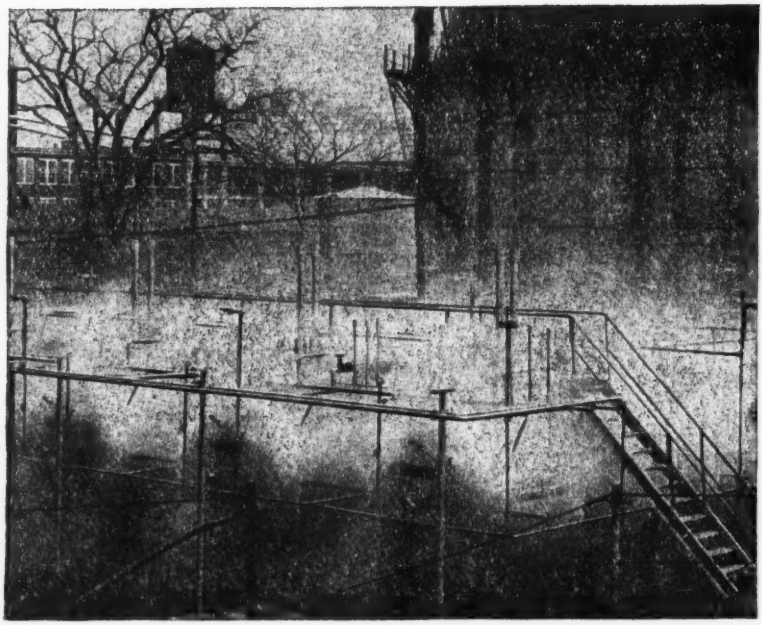

PROTECTOSPRAY SYSTEM FOR LPG STORAGE

Fire and explosion hazards from liquefied petroleum gas occur mainly when there is leakage. At such times, and if disaster is to be averted, several things become immediately necessary, whether or not ignition occurs.

1. The leak must be located and the leakage stopped. ProtectoSpray protection provides a margin of safety for the personnel doing this work.

2. Heat transfer to the storage tanks must be prevented to avoid build-up of rupturing pressure within the tanks. Properly engineered fixed water spray protection provides effective cooling of tanks to prevent pressure build-up.

3. Positive air turbulence should be provided to hasten dilution of escaped gas to make the mixture too lean to burn. Water spray, without dependence upon wind to assist it, provides sustained air movement which hastens the dilution of escaped LPG.

4. Additional inert vapor should be provided to speed the dilution of escaped LPG. Water spray is an abundant source of such inert vapor, the finer droplets in the spray vaporizing to produce inert water vapor.

5. If escaped gases ignite, the wide and evenly distributed pattern of fine water droplets from ProtectoSpray nozzles permit safe, controlled burning of gases.

There is a Grinnell Fire Protection System for every fire hazard. Grinnell Company, Inc., 274 West Exchange Street, Providence, R. I.

GRINNELL

PROTECTION AGAINST EVERY FIRE HAZARD